ALASKA MARINE SCIENCE SYMPOSIUM

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Alaska Marine Science Symposium

HOTEL CAPTAIN COOK & DENA'INA CENTER • ANCHORAGE, ALASKA


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

Glenn Aronmits

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Tuesday evening

Keynote

Preparing for the Challenges of Ocean Acidification In Alaska

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New data from ship-based and moored observations, species manipulation experiments and model outputs continue to show that ocean acidification is an imminent and potentially disruptive threat for the coastal waters of Alaska. Precipitous reductions in pH as well as the suppression of important carbonate mineral concentrations are being observed from the waterways of southeastern Alaska to the rapidly changing coastline of the Beaufort Sea. In the last two and a half centuries, but mainly in the past fifty years, the pH of the ocean has been reduced due to the intrusion of anthropogenic CO2 produced mainly from fossil fuel burning and changes in land use practices. This reduction in pH could have far-reaching and detrimental consequences for a number of marine species, particularly those that produce carbonate shells. With a multi-billion dollar fishing industry and a large subsistence population that relies heavily on ocean resources for the majority of their dietary protein, Alaska is particularly vulnerable to the impacts of ocean acidification. Here, newly synthesized economic data that provides the first assessment of the potential financial consequences of ocean acidification will be presented along with strategies for combating and adapting to changes brought on by a reduction in pH. These new strategies include the construction of a multi-million dollar network of moorings that will be capable of providing early warning data to stakeholders and policymakers throughout Alaska and the rest of the country. This project provides an ideal framework for future efforts because it harnesses resources from the state government, federal and private funding agencies and non-governmental organizations. Ocean acidification is a complex problem that will require a multilateral approach to solve, but with a concerted, well-coordinated effort we can sustain Alaska's fisheries.

Keynote

Testing the Invasion Process: Survival, Dispersal, Genetic Characterization, and Attenuation of Marine Biota on the 2011 Japanese Tsunami Marine Debris Field

Jessica A. Miller, Jessica.Miller@oregonstate.edu
Oregon State University, Department of Fisheries and Wildlife

The tsunami that was generated as a result of a magnitude 9.0 earthquake off the coast of Japan on 11 March 2011 resulted in devastating loss of human life and extensive damage to infrastructure. This natural disaster interacted with a seascape of infrastructure in a highly urbanized and industrialized setting. This potentially unique interaction delivered a field of debris that contains an unknown number of docks, vessels, buoys and aquaculture facilities potentially covered by animal and plant communities to the Pacific Ocean. A striking example of this debris field is the large floating dock from Misawa, Japan that arrived on a beach in central Oregon in early June 2012 with a diverse community of marine life (>100 species overall). The community included species commonly observed on oceanic floating debris, such as pelagic barnacles (*Lepas* sp.) but there were also other intertidal and subtidal species not currently present in Oregon. At least 12 species known to be invasive in other regions of the world have been identified, including the European blue mussel (*Mytilus galloprovincialis*), the Asian brown seaweed (*Undaria pinnatifida*), the Asian shore crab (*Hemigrapsus sanguineus*), the Japanese seastar (*Asterias amurensis*), the Asian pink barnacle (*Megabalanus rosa*), and a small tubeworm, (*Hydroides ezoensis*). We also collected many other species of mollusks, small crustaceans, worms, and an urchin. To our knowledge, no such rafted community of coastal organisms has been previously documented surviving an ocean voyage of >10,000 kilometers, nor has rafting of Asian species from the Western to the Eastern Pacific Ocean been previously observed. It is very difficult to predict the magnitude or the impact of biota arriving with the tsunami debris but a narrow opportunity exists to test critical questions in invasion theory and ecology by quantitatively, chemically and genetically documenting biota associated with the debris to evaluate both transoceanic dispersal and the potential impact of non-native Asian species. The current phenomenon provides an opportunity to advance our understanding of invasion biology by documenting key parameters, such as propagule pressure and species traits, with empirical data that we will use to quantify spatial and temporal variation in species diversity, condition and attrition.

Keynote

Chinook salmon and the marine environment

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Chinook salmon are an important cultural, commercial, and sport salmon species to the people of Alaska. Recent sharp declines in Chinook salmon returns to Alaska's rivers have lead to disaster declarations by the State of Alaska and Federal Government for some communities. The question is: "where have all the salmon gone?" Chinook salmon are anadromous, meaning their life cycle is dependent on environmental conditions in both freshwater and marine environments. Understanding the potential impacts of climate change on Chinook is complicated by the wide disparity between the effects of climate change on freshwater habitats, where long term temperatures are sharply increasing, and on the marine environment where warming occurs only very slowly, if at all. Mortality can be high and variable in both of these environments, but scientists believe the recent synchronous decline in Alaska's Chinook salmon returns is largely due to factors impacting their survival in the marine environment. We provide data on climate, distribution, migration, and diet of Chinook salmon in order to describe their marine ecology and understand effects of climate on the timing of the life cycle (phenology). The following hypotheses explaining the decline in Alaska's Chinook populations will also be discussed: 1) match – mismatch hypothesis: early marine mortality operating for all Alaskan Chinook salmon is the mismatch between timing of the life cycle in freshwater and the annual cycle of productivity in the marine environment, which is caused by the differential effects of climate change in the continental spawning and rearing areas and the nearshore marine environment; 2) critical size and period hypothesis: where climate change is effecting growth and energetic status during the first year at sea impacting marine survival over winter; 3) reduced size at age hypothesis: harvest on larger Chinook salmon has reduced fecundity in adult spawning populations leading to lower productivity.

Keynote

Technologies for ocean studies

Judith Connor, conn@mbari.org
Monterey Bay Aquarium Research Institute

When David Packard founded the Monterey Bay Aquarium Research Institute (MBARI) 25 years ago, he challenged us to develop new methods and systems to address important ocean science questions, with a goal of sharing the results with the broader science community and the public. MBARI's approach is built on teamwork of researchers and engineers and takes advantage of our ready access to the sea. Early engineering efforts focused on developing tools and techniques for the use of remotely operated vehicles for ocean exploration. The resulting high-resolution video images and data are managed as an archive of biological, chemical, geological, and physical information for research and education. The software system, the Video Annotation and Reference System developed for annotation and access to those data, is available as open-source software.

Collaborative research projects with external groups broaden the use of other MBARI technologies from a deep-sea observatory deployed in the Sargasso Sea to the high-resolution multibeam system in an autonomous underwater vehicle mapping the Canadian Arctic seafloor. Formal business partners have commercialized instrumentation such as the In Situ Ultraviolet Spectrophotometer and the Environmental Sample Processor to help get technological innovations into other research labs. We further extend our reach with intern and postdoctoral programs, and with images, lesson plans, data, and other information available on the internet to enhance interest and understanding in the ocean. These efforts have the potential to improve research access to new technology and to inspire public understanding of the ocean processes that give life to our planet.

Speakers: Arctic
Ecosystem Perspectives

A Half Century of Coastal Change Along the North Coast of Alaska

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Terrestrial portions of the Arctic coastal zone provide important feeding and breeding habitat for a number of migratory birds (e.g.black brant) and many shorebird species. Caribou use this zone for foraging and insect relief habitat. The coastal zone is also a focal point for human activity, including harvest of biological resources and infrastructure. As such, there is great interest in understanding how climate-related changes in physical processes may impact these ecosystems. A first step toward identifying vulnerable coastal ecosystems is to quantify historical erosion rates. The shoreline position for north coast Alaska barrier islands, beaches, bluffs, and most coastal lagoons for two time periods (mid 1940′s and 2000′s) were used to identify regional coastal change and potential impact to coastal ecosystems. Nearly 21,000 pairs of shoreline position data, spaced at 50 m alongshore transect intervals, document erosion and accretion rates on a coast threatened by warming sea-surface temperatures, reduced sea-ice cover, and accelerated permafrost thaw that result in potential coastal land loss and habitat destruction. Results of the shoreline change analysis are consistent with more localized previous studies and are briefly summarized here. With the exception of the major river deltas, the north coast is dominantly erosional, with an overall average erosion rate of -1.6 m/yr (range -18.6 m/yr to +10.9 m/yr). The greatest widespread erosion occurs in bluff coasts dominated by fine-grained sediment, such as the coast bordering the Teshekpuk Lake Special Area (TLSA). Lower erosion rates occur along coasts dominated by coarser sediment, typically east of the Colville River and southwest of Barrow, and in protected lagoon shorelines. Offshore barrier islands are typically non-vegetated and composed mostly of sand and gravel - these landforms are very dynamic, locally eroding and accreting as they migrate. In addition to the loss of coastal land, processes associated with erosion impact habitats through marine inundation, salinization of freshwater ecosystems, and breaching of freshwater lakes. Combining coastal erosion data with habitat maps and inundation modeling has the potential to provide improved coastal vulnerability assessments.

Speakers: Arctic
Ecosystem Perspectives

An Integrated Ecosystem Field Study of Hanna Shoal, Northern Chukchi Sea, Alaska

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The expansion of the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) into the area around Hanna Shoal reflects the growing recognition of this feature as an important habitat for a wide variety of benthic and pelagic fauna. The Hanna Shoal Ecosystem study, funded by the Bureau of Ocean Energy Management (BOEM) is a five year program of research with field studies that began in August 2012 from the USCGC Healy. Based on preliminary data and observations from the 2009 and 2010 COMIDA-CAB program funded by BOEM, the northern Chukchi Shelf receives large inputs of organic matter advected from the Bering shelf that are supplemented by local sources of primary production, including epontic ice algae, sediment microalgae and phytoplankton. Shallow depths (40-55 m) and high bottom flow facilitate high standing stocks of secondary production that are reflected in a rich benthic biota around parts of Hanna Shoal. Because of the biological significance of this region and its importance for the oil and gas industry, our multi-disciplinary focus on the benthos was expanded to address the composition and distribution of zooplankton as well as investigations of currents and circulation. We occupied 73 stations during our 16-day cruise in 2012, including nine-stations on the Distributed Biological Observatory (DBO) line across Barrow Canyon. Our preliminary observations reveal that Hanna Shoal is a highly complex, spatially heterogeneous feature with late summer ice cover that contains substantial ice algal biomass. Collaborations with other science studies in the region sponsored by federal, state, or industry interests (e.g. Shell-Conoco Philips Joint Studies Program), particularly those that will facilitate the cost-sharing of ship resources and instrument deployment on moored arrays, as well as other cooperative ventures, remain a high priority.

Speakers: Arctic
Ecosystem Perspectives

An integrated ocean observing approach to understanding the effects of climate variability in the NE Chukchi Sea

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Seasonal loss of sea ice in the Chukchi Sea shelf ecosystem has been dramatic over the past decade. The region supports protected species (walrus, seals and baleen whales), many of which are dependent, either directly or indirectly, on sea ice presence. The loss of sea ice changes the ecosystem production dynamics and opens the area to greater utilization for oil/gas extraction, commercial shipping and tourism. The BOEM-supported CHAOZ (CHukchi Acoustics, Oceanography, and Zooplankton) Project is using an integrated ocean observation approach to investigate how climate variability and change may impact this marine ecosystem and its protected species. This approach mixes broad-scale, ship-board observations during the ice free period with an array of instrumented moorings, which sample throughout the year. Critical to the integrated ocean observing approach are our clusters of biophysical moorings. The project features three pentagonal clusters of moorings centered at 40, 70, and 120 nm from Icy Cape, Alaska. Each cluster contained two or three moorings in the center to measure ice thickness, light, nitrate, chlorophyll, fluorescence, current velocity, turbidity, dissolved oxygen, temperature, and salinity. Around the outside of the cluster were passive acoustic recorders to record marine mammal vocalizations. The mid-shelf mooring cluster also contained an active acoustics device to estimate zooplankton biovolume, an important prey item of baleen whales. Water flow was northeasterly and accounted for nearly 40% of the transport through Bering Strait. Conspicuously absent during the first two years of ship-based sampling were large euphausiids from the Bering Sea. Large Atlantic species of copepods (e.g. Calanus hyperboreus) were present on the eastern side of the sampling area. Visual and acoustic monitoring of whales during the cruises also suggested low densities during August. However, the majority of detections of bearded seals as well as bowhead, fin, and beluga whales from the instrumented moorings occurred outside of the ice-free period, which underscores the importance of remote sensing in this environment. Instrumented moorings revealed other interesting observations including: a 30 m winter ice keel, significant under ice light levels, and high near bottom chlorophyll concentrations from June to September.

Speakers: Arctic

Humans

Broader Impacts ON Scientists: Results from Alaska Marine Ecosystem Workshops and the National COSEE Scientist Survey

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The National Science Foundation (NSF) created a national network of Centers for Ocean Science Education Excellence (COSEE) to improve the quantity and quality of the broader impacts on society by proving support to researchers. During 2012, COSEE-Alaska participated in a national survey on the impact of COSEE on researchers who had worked with COSEE from 2009-2011. In May 2012, COSEE-Alaska collaborated with partners to plan an Arctic Ocean Ecosystem Workshop, the third in a series focused on Alaska's Large Marine Ecosystems (Bering Sea, Gulf of Alaska, Arctic Ocean). The goals of this workshop included engaging researchers to increase science content knowledge of K-12 teachers, developing place-based educational resources, and providing experiences to researchers that would enhance their outreach skills and knowledge. Workshop organizers experimented with several factors. These included the amount of time provided to researchers and teachers to share information and collaborate, researcher-to-teacher ratios, and immersion in the local environment and Alaska Native cultures. We will summarize the results of post-workshop interviews and surveys of researchers who participated in the three workshops with respect to these variables and place the results in context of the COSEE national survey. Researchers reported more significant impacts on the way they approach research and outreach after their participation in the Alaska Ocean Ecosystem Workshop which had the longest amount of time for interaction and collaboration with teachers, a 1:1 ratio of researchers to teachers, and the greatest number of opportunities for experiencing the local environment, community, and Inupiat culture. These results are consistent with preliminary results of the national survey of researchers indicates that one significant impact of participation in COSEE programs is a change in research questions to ones that yield results that can be communicated to and applied by affected communities. The following organizations partnered in supporting the workshops which involved 28 researchers: COSEE-Alaska, AOOS, NPRB, ARCUS, Monterey Bay Aquarium Research Institute (MBARI), and Soundview Evaluation. COSEE-Alaska is a National Science Foundation-supported consortium that includes UAF School of Fisheries and Ocean Sciences, Alaska SeaLife Center, AOOS, Alaska Sea Grant and UAF Center for Cross-cultural Studies.

Speakers: Arctic

Humans

Thirty Years of Social Science Research on the North Slope of Alaska

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Since the 1980s, the ESP (Environmental Studies Program under BOEM) has funded social science research to collect baseline information for the identification and management of impacts related to offshore oil and gas development. This social science research helps fulfill BOEM's mandate to monitor oil and gas impacts and help develop mitigation to reduce the impacts of oil and gas exploration and development on the human environment. Beginning in 1982, Stephen R. Braund & Associates (SRB&A) has conducted multiple social science research projects for ESP and other entities on the North Slope of Alaska, including subsistence harvest studies, subsistence mapping and traditional knowledge studies, subsistence monitoring studies, social indicator research, and research on the effectiveness of mitigation measures meant to reduce oil and gas impacts. Together these studies have provided baseline, monitoring, and aggregate effects information and have enabled USDOI to monitor impacts of development over time. Social science research that includes traditional knowledge and human land use data are increasingly being used to inform other disciplines such as wildlife monitoring programs, climate change research, and other environmental studies that benefit from first-hand observations and knowledge of local residents. Baseline information on subsistence uses is an important tool for policy makers when developing mitigation measures and planning for future offshore development. This presentation will summarize SRB&A's research for the ESP and its implications for identifying impacts, monitoring, developing mitigation measures, and informing future policy decisions.

Speakers: Arctic
Climate & Oceanography

Climate Impacts of the Loss of Summer Sea ice in the Beaufort Sea Since 2007

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There has been a sequence of six warm, substantially sea ice-free summers in the Beaufort Sea beginning in 2007 that herald a "new normal" in Arctic climate; 2012 had an 18% decrease in northern hemisphere summer sea extent compared to the previous record in 2007, but the geographic focus was further east in the eastern Beaufort Sea. While the overall thinning of the Arctic sea ice pack is due in part to global climate change, there are additional regional coupled air-sea ice-ocean interactions that contribute to a further "Arctic Amplification". The summers of 2007-2011 in the Beaufort Sea featured strong easterly wind anomalies and an high sea level pressures (the Arctic Dipole pressure pattern) that advected Chukchi Sea water and warm, fresh water from the MacKenzie River plume to the north, causing early melting of the sea ice, followed by rapid surface warming and enhanced upper ocean heat content and stratification due to reduced surface albedo. The Beaufort Sea south of 76° N has been absorbing almost double the amount of shortwave radiation over the last five years than in the past, roughly enough to melt 1.5 x 106 km2 of 1 m thick sea ice each year. The consequence of this heating was revealed by waveglider and satellite measurements of 6-10 C ocean temperatures in the upper 6 meters during summer 2011, perhaps the largest temperature anomalies of the Northern Hemisphere. The causes of the unusual Beaufort weather pattern of the summers of 2007-2011 may relate to increased atmospheric pressure over North America and Greenland. The added upper ocean warmth means a late start to ice formation in the fall, and hence anomalous heating of the atmosphere. This added heating disrupts the Arctic atmospheric circulation causing regional atmospheric flow meanders potentially causing extreme weather events, as persistent Arctic climate change interacts with chaotic mid-latitude atmospheric dynamics.

A sea ice free summer Arctic within 30 years: An update from CMIP5 models

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The fate of Arctic marine ecosystems is clearly connected to that of the sea ice. Reduced ice coverage is expected to change the size and species composition of plankton, with significant ramifications for harvestable production, key fish species, ice-bound fauna and air-sea carbon dioxide exchange. With a new record of summer minimum sea ice extent reached in the Arctic in 2012, the question "how soon will the Arctic be ice free" is once again a focal point not only among scientists. Three years ago we proposed that the summer Arctic would be nearly sea ice free by the 2030s; "nearly" is interpreted as sea ice extent less than 1.0 million km2. We consider this estimate to be still valid based on projections of updated climate models (CMIP5) and observational data. Reduction in ice thickness and ice volume is another measure of fast changing Arctic sea ice conditions. Similar to previous models (CMIP3), CMIP5 still shows a wide spread in hindcast and projected sea ice loss among different models. Further, there is no consensus in the scientific literature for the cause of such a spread in results for CMIP3 and CMIP5. All CMIP5 models do show loss of sea ice due to increased anthropogenic forcing relative to preindustrial control runs. Applying the same technique of model selection and extrapolation approach to CMIP5 as we used in our previous paper, the interval range for a nearly sea ice free Arctic is 14 to 36 years, with a median value of 28 years. Relative to a 2007 baseline, this suggests a nearly sea ice free Arctic in the 2030s.

Speakers: Arctic
Climate & Oceanography

Modeling Ice and Circulation in the Chukchi and Beaufort Seas

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We present results from a suite of 20-year hindcasts of Chukchi/Beaufort ocean and ice conditions and compare these to moored, drifter, ship-based, and remotely sensed observations of ocean velocity, hydrography and ice concentrations. The numerical model employs the Regional Ocean Modeling System (ROMS) framework, using a telescoping grid that encompasses the whole of the Arctic Ocean and resolves the study region with ~ 5 km horizontal grid spacing and 50 vertical layers. The model-data comparisons help guide model improvements in a design-evaluate-iterate loop and provide a basis for interpreting model results at places and times in which no observations exist. Potential model applications include oil spill tracking, improved nowcast and forecast ocean-ice prediction systems, and retrospective analyses applied to regional oceanography and climate studies. Initial results show that the model is able to reproduce approximately one-half of the observed integrated monthly ice concentration anomaly in the study region. In addition, the model captures fundamental changes in the nature of the shelf circulation and hydrographic properties as the system progresses from partial ice cover in summer to full ice cover in winter. We describe some of the novel approaches to modeling this region employed in our project and provide examples of the model-data comparisons.

The Chukchi-Beaufort Seas Mesoscale Meteorological Modeling Project: An Overview of High-Resolution Atmospheric Reanalysis (CBHAR)

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The Chukchi-Beaufort Seas (CBS) and their adjacent coastal and inland areas have experienced drastic changes across all climate system components, as strikingly evidenced by a rapid reduction in summer sea ice coverage and a considerable increase in ocean and atmospheric temperatures. At the same time, anomalous weather patterns and extreme events have been more frequently observed in this region. These changes may increase the threat to both national energy security and the environment, due to potential infrastructure destruction and resultant oil spills. It is therefore vitally important to realistically describe and thus better understand high-resolution meteorological fields, particularly surface winds, in this area. This presentation will provide an overview of our project, and a general introduction to our recently-completed Chukchi-Beaufort High-Resolution Atmospheric Reanalysis (CBHAR), produced for the period 1979–2009. To develop this reanalysis product, we established a three-dimensional assimilation system based on the state-of-the-art Weather Research and Forecasting (WRF) model with model physics and initial and boundary conditions optimized for this region. The reanalysis was constrained by surface and satellite-based observations collected throughout the study area and subjected to rigorous quality control procedures. The WRF model and its assimilation system were configured to generate gridded surface winds, along with other meteorological parameters, at high spatial (10 km) and temporal (1 hour) resolutions. This high-resolution data is crucial for resolving and better understanding high-frequency wind variability and finer-scale extreme weather events, such as the intense polar low observed during 9-10 October 2009, which will help to improve the simulation and understanding of ocean eddies and boundary currents, and consequently the assessment and prediction of oil spill dispersion, ocean waves, and coastal erosion. Verification of CBHAR against surface-based observational data indicates that the reanalysis realistically captures observed climatology, variability, and long-term changes of surface winds and temperatures, with a marked increase in accuracy relative to the new generation of global reanalysis products. Analysis of this new data also suggests a large seasonal variation in the surface wind pattern and an increase in wind speed over the CBS throughout the last 30 years. These changes may have broader implications for environment.

Speakers: Arctic

Climate & Oceanography

Leads and Landfast Ice in the Beaufort and Chukchi Seas

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The Arctic Ocean region is in the midst of major environmental and socio-economic transformations. Dramatic changes have occurred in the US Arctic where the loss of summertime sea ice extent has been most pronounced and operations associated with oil and gas exploration have been most active. Here, we present results from an extensive analysis of remote sensing data spanning both the Chukchi and Beaufort Seas over a period of more than a decade, at a time of dramatic changes in the sea ice cover. Using clear-sky AVHRR imagery for the period December 1993 to June 2010, we have qualitatively identified distinct recurring patterns of leads and quantified the number, size and mean areal fraction of leads. We also mapped landfast sea ice extent at approximately10-day intervals through analysis of consecutive mosaics of Radarsat SAR data for the period November 1996 – April 2008. Examination of lead statistics shows a marked contrast between the Chukchi and Beaufort Seas, with the former having significantly higher number and areal fraction of leads than the latter. However, our results also point to a dramatic change beginning in the early 2000s such that lead patterns in the Beaufort Sea have more closely resembled those in the Chukchi Sea in recent years. The extent and timing of landfast sea ice also differs between the two seas, with landfast ice in the Beaufort Sea being generally more extensive and longer lasting than that in Chukchi Sea. However, we find that local variability is of a similar magnitude to regional-scale differences. Timeseries analysis reveals significant trends toward later formation and earlier breakup along certain sections of coast. This is in agreement with a comparison with data from the1970s. In general, we find that the extent of landfast ice has remained relatively constant over time, but there are notable cases where landfast ice extent was anomalously low, such as in the Beaufort Sea following the pronounced loss of multiyear ice in the Arctic in 2006. We anticipate further analysis of these cases will shed light on the response of landfast ice to broader changes in the Arctic.

Speakers: Arctic

Climate & Oceanography

High-resolution observations of hydrography and circulation of the Chukchi Sea

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We present an overview of a comprehensive suite of observations from the Chukchi Sea consisting of land-based high-frequency radar, sub-surface moorings, AUV gliders, towed vehicles, and satellite-tracked drifters, designed to sample and understand the hydrography and circulation of the northwestern Chukchi Sea at high spatial and temporal resolutions previously unattained in the Arctic Ocean. The relatively shallow shelf responds to southerly or mild easterly winds with flow into Barrow Canyon that includes water moving eastward from the central Chukchi shelf and merging with coastal water flowing northeastward along the Alaskan coast. Strong northeasterly winds reverse the shelf circulation, and occasionally introduce upwelled waters on the Chukchi shelf, originating from the deep Arctic basin. Detailed hydrographic sections sampled by autonomous and towed vehicles show a complex hydrographic structure that responds to both wind forcing, air-sea-ice interaction and internal mixing processes. Horizontal density gradients in the surface layer (fronts) are shown to extend down to O(1) km submesoscales. These, previously unresolved submesoscale fronts, play an important role in setting surface-layer properties by restratifying the surface layer, in opposition to forcing such as wind that vertically mix the surface ocean. Lastly, we show preliminary results from the 2012 season, where we in collaboration with the North Slope Borough and NOAA/PMEL deployed ~100 satellite-tracked drifters across the northwestern Chukchi Sea. The drifter trajectories show clearly how the circulation was dominated by the presence of sea ice over the Hanna Shoal region, and how large-scale fronts separated the flow into different advection pathways, including energetic onshore-alongshore flow and more stagnant flow in the ice-dominated offshore regions.

Speakers: Arctic
Lower Trophic Levels

Using imaging flow cytometry to examine phytoplankton assemblage structure in the Bering and Chukchi Seas

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A new technology, automated individual cell imaging, was used to assess the composition of phytoplankton assemblages in the Bering and Chukchi Seas in summer 2010 and 2011, and in early winter 2011. Significant differences were observed in these two summer periods in the structure and distribution of nano and microplankton assemblages. A major feature observed in summer 2011 was a massive under-ice bloom of diatoms west of Hanna Shoal. Winter phytoplankton assemblages, although considerably lower in terms of biomass, also revealed substantial spatial structure dominated by dinoflagellates and some diatom taxa. Such detailed information on nano and microplankton assemblage composition, coupled with concurrent sampling of smaller cells using standard flow cytometry, provide an unprecedented view into the spatial structure of phytoplankton communities in the Bering and Chukchi Seas. This insight helps to advance understanding of how the complex physics and chemistry of these two seas control the distribution and timing of phytoplankton production.

Zooplankton of the Chukchi and northern Bering Sea in Early Winter – Results from the 2011 November-December Cruise on USCGC Healy

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Our understanding of seasonality, and particularly winter conditions, in the Arctic is severely limited because of difficulties in accessing these regions during winter. This lack of knowledge has compromised our ability to model and to predict Arctic ecosystems, knowledge that is critical to our efforts to understand the potential impacts of ongoing climate change. In particular, we knew little about the overwintering strategies of Calanus glacialis/marshallae (Calanus spp.) on the shallow Chukchi and Bering Seas. In November-December 2011 we conducted a cruise on the USCGC Healy to the Bering and Chukchi Seas, sampling along key transects. Our objectives included describing hydrography, circulation and associated zooplankton species and population distributions, identifying the overwintering habitat, activity, and grazing rates of Calanus spp. and euphausiids, and quantifying the course- and fine-scale vertical distributions of plankton and particles in relation to the vertical structure of the water column. We found Calanus spp. and euphausiids to be widespread across the study area. At most locations, the dominant life stage of Calanus spp. was copepodid V, with copepodid IV more important along the Chukchi Shelf break and in the Canada Basin. Surprisingly, adult males often constituted >50% of the total adults. Euphausiids also were widespread across the region. Both Calanus spp. and euphausiids both appeared to be active, with Calanus spp. not in diapause but rather continuing to develop. Lipid deposition of Calanus spp. was well developed and the C/N ratio of the animals was high. Both Calanus spp. and euphausiids had measurable grazing rates on phytoplankton, although at very low levels as expected in the low chlorophyll environment.

Speakers: Arctic
Lower Trophic Levels

Indigenous Arctic Microorganisms Degrade Oil in Arctic Seawater

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A number of techniques can be used to respond to a marine oil spill such as mechanical recovery, in situ burning, the application of dispersants and natural attenuation. The success of the latter two options relies upon biodegradation by indigenous microorganisms. As oil exploration expands in offshore Arctic regions, it is imperative to assess the potential rate and extent of oil biodegradation by indigenous microorganisms under environmentally relevant temperatures. A respirometry experiment validated with chemical analyses was conducted in order to determine the potential for indigenous arctic marine microorganisms to biodegrade Alaskan North Slope (ANS) crude oil in the presence or absence of a dispersant (Corexit 9500), in late winter/early spring conditions. Sea water was collected from the Beaufort and Chukchi Seas to provide an indigenous consortium of biodegrading microorganisms. Tests were conducted with fresh seawater at an on-site laboratory (Barrow, Alaska), at -1°C, with minimal nutrient addition. Respirometry combined with chemical analyses was used to evaluate the rate and extent of biodegradation. Biodegradation and mineralization occurred in fresh and 20% weathered ANS crude at -1°C with indigenous Arctic microorganisms. The presence of Corexit 9500 was not inhibitory to natural microbial degradation. The addition of Corexit 9500 enhanced the initial degradation of both fresh and weathered oil both in the presence and absence of low-level nutrients.

Speakers: Arctic
Fish and Fish Habitat

The Arctic Ecosystem Integrated Survey (Arctic Eis)

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Management agencies with responsibilities for Arctic marine waters, such as the Bureau of Ocean Energy Management (BOEM), the US Fish and Wildlife Service (USFWS), and the National Oceanic and Atmospheric Administration (NOAA) require baseline information for the Chukchi Sea to adequately assess impacts on fish, shellfish, seabird and marine mammal populations from potential exploitation, oil and gas development, and climate change. Significant gaps currently exist in our understanding of the marine environment of the Chukchi Sea, particularly with regards to fish communities. In the fall of 2012, we completed the first field season of the Arctic Ecosystem Integrated Survey, which surveyed the oceanography, plankton, fish, epibenthic invertebrates, and seabirds over the entire eastern Chukchi Sea shelf. This study will provide enhanced baseline information for the region and will fill significant gaps in our understanding of the population structure, trophic role, and life history of key fish and crab species. The overall goal of the study is to contribute to a comprehensive assessment of the eastern Chukchi Sea shelf ecosystem and to evaluate results relative to earlier studies in the same area and relative to similar studies in adjacent regions through a combination of field and laboratory studies, modeling, retrospective analyses, and data syntheses. These efforts will be coordinated with and are intended to complement ongoing work. We provide an overview of the project and present preliminary results on the distribution and abundance of demersal and pelagic fish species during August and September 2012.

Dispersal of adult Dolly Varden from the Wulik River, Alaska, evaluated using satellite telemetry

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In northwest Alaska, Dolly Varden is highly valued as a subsistence fish and local residents harvest thousands of these fish each year. Many of these Dolly Varden undertake oceanic migrations during summers, yet little is known about their dispersal and distribution during this time. We studied the oceanic dispersal of Dolly Varden by attaching miniaturized pop-up satellite archival transmitting (PSAT) tags to 20 Dolly Varden in the Wulik River in early June 2012. PSAT tags measured and recorded temperature, depth and ambient light data for daily geoposition estimates at 10 minute intervals while externally attached to the fish. The tags released from the fish, floated to the surface of the sea and transmitted, via satellite, the pop-up position and archived data. The tagged fish demonstrated several dispersal types including: remaining at the tagging site (n=3), limited movement to the Wulik River mouth (n=3), southerly alongshore dispersal (n=3) and northerly offshore dispersal to the Russian Chukchi Sea (n=5) and the Alaskan Beaufort Sea (n=1). In addition, three tags reported to satellites, but no positional fixes were obtained, likely as a result of the tags not being in saltwater. Finally, two tags did not report to satellites. These results suggest that Dolly Varden that overwinter in the Wulik River undertake a variety of summer dispersal strategies including transit through and occupancy of areas that may be impacted by future human activities.

Post-breeding shorebird use of food resources at river deltas along the Beaufort Sea Coast

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The Beaufort Coast is the first stop in the fall migration for many shorebirds, and change in this habitat could negatively impact the rest of their migration. We collected data on shorebird use and macroinvertebrate abundance during the late summer (2009 – 2012) at the Canning, Okpilak/Hulahula, and Jago River deltas along the Beaufort Sea coast of the Arctic National Wildlife Refuge. This research elucidates the relationship between shorebirds and their food resources, provides baseline information on delta macroinvertebrates, and investigates potential climate change impacts on the birds and invertebrates. We used a grid sampling design to collect spatially explicit information; we found macroinvertebrates were patchily distributed by taxa and among study sites. The macroinvertebrate community was dominated by freshwater species at the Jago and Okpilak/Hulahula deltas and by saltwater species at the Canning Delta. Some taxa such as Chironomidae and Oligiochaeta were associated with muddy sediments suggesting that invertebrate communities may differ as a result of changes in contributions of river sediments due to melting glaciers in the Brooks Range. Shorebirds used all of the deltas when food was available, but flocks focused their feeding in areas where food resources were abundant. This preliminary research will help answer more complex questions determining the role of delta mudflats in the autumnal migration of shorebirds.

Speakers: Arctic
Seabirds

Complex Foodweb Dynamics of the Marine Bird Communities of the High and Low Arctic

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Understanding the complex dynamics of environmental change in northern latitudes is particularly critical for Arctic avian communities, which are integral components that maintain biological teleconnections between the mid- and northern latitudes. Furthermore, polar birds are fundamental to Native subsistence lifestyles and serve as foci for conservation and ecological research. This project has several objectives: to quantify the network dynamics of marine bird foodwebs, to understand the nature of their recent and past changes, and determine how High and Low Arctic patterns may be related to climate change. We use several data sources and analysis techniques, including diet data, stable isotopes, and network analysis for comparable marine bird communities from Subarctic and High Arctic regions (eg., Aleutians, Bering Sea, NW Greenland). Our preliminary results indicate that community-wide spatial and temporal dynamics of marine bird ecosystems are similar, but that the magnitude of change is greater in the High Arctic communities. In particular, we show that the ecological patterns observed within such widespread Arctic species as Thick-billed Murre Uria lomvia, Black-legged Kittiwake Rissa tridactyla, and Northern Fulmar Fulmarus glacialis, indicate diets strongly perturbed from a decade earlier. We hypothesize that these changes are related to oceanographic and trophic-level responses to increased freshwater injection into coastal waters and fine-scale alterations in oceanography.

Speakers: Arctic
Marine Mammals

Sixty years of bowhead whale stable isotope geochemistry and linkages to the rapidly changing Arctic

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Ice associated bowhead whales (Balaena mysticetus) live in an environment that is undergoing dramatic change. Sea ice loss has accelerated in recent decades, thereby increasing the availability of open water habitats in the Arctic. This may lead to shifts from ice algae- to pelagic phytoplankton-dominated food webs, bottom-up trophic cascades, and altered distribution and migration patterns of megafauna. We used carbon and nitrogen stable isotopes, natural tracers that can indicate habitat change, trophic shifts, and biogeochemical changes at the base of the food web, to study long-term trends in the ecology of zooplanktivorous bowhead whales. We produced multi-decadal δ13C (1954-2010) and δ15N (1966-2010) stable isotope records by sampling the metabolically inert baleen plates of 75 sub-adult or adult bowhead whales. Several environmental and climatological records, including atmospheric carbon dioxide concentration, Arctic sea ice extent, Pacific Decadal Oscillation Index, and El Nino Southern Oscillation Index, were also examined to determine relationships between the bowhead whale isotope data and the ecosystems in which the whales forage. The bowhead δ13C record decreased steadily from 1967-2000 at a rate of -0.05‰ yr-1, while the δ15N record remained stable over the same period. This decrease in δ13C was strongly correlated with an increase of fossil fuel derived (and δ13C "light") atmospheric carbon dioxide over the same time period. In 2000, these trends changed abruptly: both isotope records began to increase at a rate of 0.06‰ yr-1 at the same time that the decline of summer sea ice began to accelerate. We hypothesize that the post-2000 bowhead whale baleen isotope time series documents a steady increase in Arctic primary production owing to larger areas of open water and protracted growing seasons. An increase in the rate of primary production leads to enrichment in both carbon and nitrogen isotopes due to kinematic fractionation, which we expect to propagate to bowhead whales via trophic transfer. We propose that bowhead whales can serve as an ecosystem sentinel, whereby stable isotopes of easily accessible, Inuit-harvested, bowhead whale baleen can continue to be used to measure ecosystem-integrated changes in the Arctic.

Speakers: Arctic
Marine Mammals

Bowhead Whale Feeding Ecology Study (BOWFEST) - Five years in review

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The feeding ecology of bowhead whales (Balaena mysticetus) has been a focus of interest for whalers, biologists, and managers on the North Slope of Alaska, particularly in regard to potential developments proposed by petroleum industry. In response to these interests and concerns, a research program, the Bowhead Whale Feeding Ecology Study (BOWFEST), was initiated in 2007 through an Interagency Agreement between the Bureau of Ocean Energy Management (BOEM) and the National Marine Mammal Laboratory (NMML). The study was conducted by scientists at Woods Hole Oceanographic Institution (WHOI), University of Rhode Island (URI), University of Alaska Fairbanks (UAF), University of Washington (UW), Oregon State University (OSU), and NMML. Field work was coordinated with the North Slope Borough (NSB).This study focused on late summer oceanography and prey densities relative to bowhead whale distribution over continental shelf waters between the coast and 72°N and between 152º -157º W. Aerial surveys and acoustic monitoring provided information on the spatial and temporal distribution of bowhead whales in the study area. Oceanographic sampling helped identify sources of zooplankton prey available to whales on the continental shelf and the association of this prey with physical (hydrography, currents) characteristics which may affect mechanisms of plankton aggregation. Results of this research program may help explain increased occurrences of bowhead whales feeding in the Western Beaufort Sea, well west of the typical summer feeding aggregations in the Canadian Beaufort Sea. Understanding bowhead whale behavior and distribution is necessary to minimize potential impacts from petroleum development activities.

An index of optimum sustainable population for the Pacific Walrus

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The Marine Mammal Protection Act specified that marine mammal stocks be maintained at an optimum sustainable population level (OSP). Determining OSP for most stocks was not possible and indices to OSP were soon proposed, but many were equally difficult to develop. The OSP management model was replaced with the concept of potential biological removal (PBR) in 1994 and estimates of PBR have been a part of marine mammal stock assessments to this day. However, PBR is very conservative and was designed to assess marine mammal-fisheries interactions where management agencies have substantial control. The greatest source of human caused mortality of Pacific walruses (Odobenus rosmarus divergens) is the subsistence hunt by Alaskan and Chukotkan Natives which is exempt from most of the provisions of the MMPA and the Endangered Species Act. Thus, tracking the population status relative to OSP may be a more useful management tool. In this study, we assessed the potential of calf:cow ratios (CCR) estimated form harvest data as an index to OSP. Calf:cow ratio estimates meet many of the characteristics of a useful index including a strong inverse relationship to population size, ease of estimation, straightforward interpretation, small variance, greatest rate of change near maximum productivity, etc. Based on abundance estimates when the Pacific walrus population was near or at carrying capacity and a simulated estimate of maximum net productivity, CCRs of 0.40-0.46 reflect a Pacific walrus population within OSP. However, it will be difficult to meet the OSP mandate primarily due to the narrow range of OSP and time lags in population response to management actions. The best use of the CCR index is likely in keeping Native subsistence hunters informed of the status of the population to promote self-regulation of the harvest by those hunters.

Speakers: Arctic
Marine Mammals

Acoustic detection of bearded seals (*Erignathus barbatus*) in the Bering, Chukchi, and Beaufort Seas 2008 – 2011

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Dramatic shifts in Arctic climate have led to changes in sea ice distribution and timing that pose adaptability challenges for polar species. Ice obligate species, such as the bearded seal (*Erignathus barbatus*), are inherently vulnerable to environmental change due to their reliance on seasonal sea ice as a platform for pupping and molting. Bearded seals are a highly vocal pan-Arctic species, and males produce underwater vocal displays as part of courtship behavior during mating season. Year-round passive acoustic data were examined for bearded seal presence at eight locations in the Bering, Chukchi and Beaufort Seas between 2008 and 2011 to assess their seasonal movements and habitat use. Passive acoustic data were collected using hydrophone packages (Multi-electronique Aural M-2) with an effective bandwidth between 10-8000 Hz and a 20% or 30% duty cycle. Instruments were moored at depths between 45 – 175 m. Bearded seal vocalizations were detected manually and compared with sea ice concentration and in situ water temperature. At Beaufort and Chukchi Sea locations, bearded seal vocalizations were detected year-round, but were only detected in the spring at sites in the Bering Sea. Peaks in vocal activity varied between regions as well as years and were associated with regional sea ice conditions. Nearly continuous vocal activity occurred in the Beaufort and Chukchi Seas between January and July for all years, but only between February and May in the Bering Sea. No calls were detected in the Bering Sea outside the known breeding season. Seasonal sea ice was present in the Beaufort and Chukchi Seas from late autumn through early summer, nearly five months longer than in the Bering Sea. The difference in availability of sea ice habitat between the regions may have influenced the presence of vocalizing bearded seals. The autumn/winter presence of bearded seals in the Beaufort and Chukchi Seas during the open water period suggests possible year-round residency of a small subpopulation of bearded seals. Characterization of year-round bearded seal acoustic activity will facilitate development of historical baselines needed for detecting future population fluctuations.

Spatial Use Patterns of Ribbon and Spotted Seals in the Bering and Chukchi Seas

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Ribbon and spotted seals rely on the seasonal sea-ice of the Bering Sea for pupping and breeding, yet information vital to understanding seasonal changes in the spatial use patterns of these species is scarce. Between 2007 and 2010, 40 ribbon seals and 22 spotted seals were captured in the central and western Bering Sea and released with satellite tags. Locations from these tags informed a continuous-time correlated random walk state-space model and importance sampling was used to incorporate location and model uncertainty into a spatial use analysis. In addition to the state space model approach, the location error model employed in this analysis is one of the first to rely on the newly implemented Argos kalman filter algorithm. Spatial use grids were created for each species across three seasons. March to May represents the pupping and breeding period, June to October is relatively ice-free in the Bering and Chukchi seas and November to February relates to increasing ice coverage. The use grids show tagged individuals from both species were concentrated within the marginal sea-ice zone during pupping and breeding. During the relatively ice-free period, ribbon seals expanded their range north along the Russian coast into the eastern Chukchi and Arctic Ocean and as far south and east into the Gulf of Alaska. During this same period, spotted seals remained almost entirely on the Bering and Chukchi shelf. The average portion of time spent north of the Bering Strait during this time for ribbon seals was 0.095 (sd: 0.257) and 0.261 (sd:0.372) for spotted seals. The range of both species shrank as ice coverage increased between November and February. This study provides important insight into the seasonal spatial-use patterns of ribbon and spotted seals and will be a key foundation for understanding how these species may be impacted by future reduced sea-ice coverage.

Speakers: Arctic
Marine Mammals

Variation in the nutritional and reproductive ecology of two polar bear populations experiencing sea ice loss

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Comparative studies of ecological responses to climate change are needed to improve population and species projections in the face of continued global warming. In this study, we evaluated the ecological status of polar bear populations in the Chukchi (CS) and southern Beaufort seas (SB) in relation to sea ice availability. We compared the body size, condition, and reproduction of CS and SB bears from 2008-2011 to investigate spatial variation in responses to sea ice loss; and with CS data collected 1986-1994 to investigate temporal responses. We also evaluated how observed variation in body condition and reproduction were related to feeding ecology. Compared to the SB during 2008-2011, the CS had half as many ice-free days over continental shelf waters. CS polar bears were larger and in better condition, and appeared to have higher reproduction than SB bears. Although CS and SB bears had similar diets, twice as many bears were fasting in spring in the SB than the CS. Between 1986-1994 and 2008-2011, body size, condition, and reproduction in the CS were not reduced despite a 44-day increase in the number of ice-free days. Furthermore, bears in the CS exhibited large body size, good body condition, and high indices of recruitment compared to most other populations measured to date. We propose that higher biological productivity and prey availability in the CS relative to the SB and a shorter history of exposure to reduced sea ice habitat likely explain the maintenance of condition and reproduction. Spatial and temporal differences in the response of polar bears to climate change are relevant to range-wide forecasts for this and other ice-dependent species. Similar responses in ringed seals and polar bears to sea ice loss in the CS and SB suggest that ecosystem-based projections may be a fruitful path of future research and conservation efforts

Speakers: Bering Sea and Aleutian Islands
Ecosystem Perspectives

What controls trophic interconnectivity in the eastern Bering Sea?

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The Bering Sea is one of the world's most productive marine ecosystems, sustaining nearly half the U.S. annual commercial fish catch and providing food and cultural value to thousands of coastal and island residents. Seasonal sea ice is recognized as a central driver of this ecosystem, and recent climate-related changes in the extent of sea ice have highlighted the vulnerability of the ecosystem to loss of sea ice. However, our mechanistic understanding of that vulnerability remains poor. The "Bering Sea Project" integrates the NSF Bering Ecosystem Study (BEST) and the NPRB Bering Sea Integrated Ecosystem Research Program (BSIERP) bringing nearly a hundred principal scientists together in a vertically integrated observational and modeling program aimed at understanding the impacts of changes in seasonal sea-ice and physics on the ecosystem from phytoplankton to people. The Bering Sea Project is now in the synthesis phase and several key observations are emerging. First, clear differences in mean current patterns on the shelf between warm years (less sea ice) and cold years (more sea ice) are related to differences in the geographic distribution of early stages of walleye pollock and may decouple them from their food. Furthermore, the geographic expansion of pollock in warm years was not reversed in the recent cold period suggesting an indirect impact of temperature on pollock. Second, primary production and net community production are more closely tied to seasonal meteorological forcing rather than to the extent of sea ice. Elevated primary production in warm years does not appear to result in increased net community production suggesting a remaining gap in understanding the flow of carbon between the first few trophic levels. Third, the importance of microzooplankton to the Bering Sea ecosystem has been well established and available data suggests that it may be a more important intermediary between phytoplankton and large crustacean zooplankton (an important dietary component for the survival of overwintering juvenile pollock), in warm years than cold years. Lastly, pollock do not appear to be the dominant control on the abundance of crustacean zooplankton as hypothesized; environmental controls on growth and distribution of zooplankton are more important.

Declines of top predators in the central Bering Sea: Are Pribilof seabirds and fur seals living in the wrong neighborhood?

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We undertook a comparative analysis to determine why northern fur seals, thick-billed murres and black-legged kittiwakes are thriving on Bogoslof Island (southern Bering Sea) and declining on St. Paul Island (Pribilof Islands – central Bering Sea). We assessed the abundance and distribution of prey around each breeding colony (Jul–Aug 2009), and concurrently determined diets, stress levels, and foraging locations of these three top predators. Birds and seals from the Pribilof Islands were found to travel further and for longer times to feed, and experienced higher stress levels compared to those from Bogoslof Island. Diets of fur seals and murres on St. Paul Island were dominated by juvenile pollock (low energy content), whereas diets on Bogoslof were dominated by high energy mesopelagic species (squids for murres; myctophids for kittiwakes; squids and northern smoothtongue for seals). At-sea distributions of birds and mammals were relatively uniform across the Bering Sea, but distinct between breeding islands. Seal and seabird distributions corresponded with the broad scale distribution of widely dispersed shallow patches of prey—and not with the total biomass or numerical abundance of their dominant prey species. Quality of diets (i.e., energy density) and their accessibility may drive reproductive success of birds and seals in the Bering Sea. Recovery of northern fur seals, thick-billed murres, and black-legged kittiwakes on the Pribilof Islands to numbers present prior to the 1975/76 regime shift will likely require a dietary increase in energy-rich cephalopods and mesopelagic fishes.

Identifying important ecological areas in the Aleutian Islands

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Practical approaches are needed to preserve the health, biodiversity, and resilience of marine ecosystems. Identification of Important Ecological Areas (IEAs) provides a systematic way to prioritize spatial conservation, response, and restoration efforts. We present an analytical method for identifying IEAs using the region of the Aleutian Islands from the east side of Umnak Island to the western edge of the U.S. Exclusive Economic Zone past Attu Island as a case study. Once identified, IEAs should be incorporated into management efforts to avoid unnecessary impacts associated with the exploitation of marine resources. We define Important Ecological Areas as geographically delineated areas which by themselves or in a network have distinguishing ecological characteristics, are important for maintaining habitat heterogeneity or the viability of a species, or contribute disproportionately to an ecosystem's health, including its productivity, biodiversity, functioning, structure, or resilience. For example, areas that are migration routes, subsistence areas, sensitive seafloor habitats, breeding and spawning areas, foraging areas, and areas of high primary productivity. As an exercise in valuation, determining "relative importance" requires a process for establishing and comparing values of individual or multiple ecological features on a similar scale, which is accomplished using standard deviates. Ecological features used in this case study included primary productivity, relative abundance of groundfish, marine mammals, seabirds, and habitat-forming invertebrates for which datasets were available. The study region was divided into a 5X5 km grid of planning units. Spatial data for each ecological feature was overlaid on the grid and values for each planning unit calculated. This created a distribution of planning unit values for an ecological feature and values were then converted to standard deviates. Positive standard deviates from the different ecological features were added to provide a landscape of relative importance. Variability in the relative importance of planning units was found across the study region. Further analyses were conducted on common fish species caught in the standard groundfish trawl survey. This rich data set was used to test several methodological assumptions as well as examine the robustness, significance and proportion of variance explained.

Speakers: Bering Sea and Aleutian Islands
Ecosystem Perspectives

Distribution of corals and sponges in two large canyons on the Bering Sea shelf break

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Two of the largest submarine canyons in the world, Zhemchug and Pribilof, cut into the edge of the continental shelf in the southeastern Bering Sea. A submersible was used to conduct systematic video transects of the sea floor. Dozens of specimens were collected and preserved for analysis. Data are presented showing the distribution of corals and sponges from research undertaken in 2007 and 2012. High densities of gorgonian and pennatulacean corals and sponges are present in the canyons likely due to enhanced surface productivity at the shelf edge, combined with benthic currents and seafloor topography. Rockfishes, including the commercially important Pacific Ocean perch, *Sebastes alutus*, were associated with corals and sponges as well as with isolated boulders. Sculpins and poachers were also associated with corals in Pribilof Canyon, where corals were most abundant. Fishes likely use corals and sponges as sources of vertical relief, which may harbor prey as well as provide shelter from predators. Boulders are also habitat in this regard, but are generally sparse in deep water habitats, including in the canyons, strongly suggesting that biogenic structure is important fish habitat there. Evidence of disturbance to the benthos from fishing activities was observed in these remote canyons. Bottom trawling and other benthic fishing gear has been shown to damage corals and sponges that may be very slow to recover from such disturbance. Establishment of conservation zones is a cost effective means to protect benthic habitats in these canyons and the ecosystem services they provide.

Speakers: Bering Sea and Aleutian Islands
Humans

Targeting ability under rights-based management: The Amendment 80 Bering Sea/Aleutian Islands groundfish fishery

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The incentives generated under command and control fishery management regimes can often result in a "race to fish" environment, leading to biological and economic waste. Rights-based management attempts to curtail these perverse incentives by granting fishermen or groups of fishermen the exclusive right to harvest a share of the total allowable catch (TAC). While rights-based management systems have a strong track record, their use has often been in single-species fisheries. Multispecies fisheries add an additional layer of complexity. Fishing gear that is not perfectly selective may make it difficult for fishermen to match their catch composition with management-determined TAC compositions. Possible consequences include illegal discarding, data fouling, and unfished TACs. In theory, fishermen can increase their ability to "target" catch using imperfectly selective gear by modifying how the gear is employed. For example, adjusting speed, depth, and/or area of tow can potentially enhance targeting ability of bottom trawlers. Previous ex ante examinations of targeting ability using data from non-rights-based fisheries suggest that rights-based systems may face serious challenges due to weak substitution potential between species. However, targeting "ability" may be confounded with a lack of incentives to substitute between species under non-rights-based institutions. We investigate this claim through an examination of the Bering Sea/Aleutian Island (BSAI) groundfish trawl fishery. In 2008, the North Pacific Fisheries Management Council rationalized the BSAI groundfish fishery under Amendment 80 (A-80). Under A-80, shares of the TACs for several target and non-target species are allocated to individual fishermen that are vested in either a cooperative or in a common pool fishery. We use a detailed dataset of vessels from before and after A-80 to study the extent to which A-80 influences the catch composition of fishermen. We find that fishermen are remarkably capable of adjusting their catch composition under the new incentives in A-80 through strategic gear deployment over time and space. This suggests that fishing technologies may be far more flexible and selective than is often predicted from data gathered prior to a policy change.

Permit stacking in Bristol Bay

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In the December of 2009, the Alaska Board of Fisheries met for the Bristol Bay Finfish meeting. Proposal 17 in this meeting included provisions for permit stacking in the Bristol Bay set gillnet fishery. Permit stacking allows for the use of a second permit by a permit holder to double the maximum amount of net he or she can deploy when prosecuting this fishery. The stacking proposal passed and went into effect in 2010 with a sunset clause due to expire by the end of 2012. Multiple proposals were submitted for the December, 2012 Board of Fisheries Bristol Bay Finfish meeting to remove the sunset clause, thus allowing permit stacking to go on into perpetuity. In this paper, I quantitatively explore the effects of this policy change on Bristol Bay set gillnet holders by observing real earnings, permit prices, and landings. Discussed are topics such as changes in permit distribution, the use of emergency transfer permits, changes in the permit price and how this policy affects the proportion of landings among resident classes.

Speakers: Bering Sea and Aleutian Islands

Humans

Using traditional knowledge interviews and participatory mapping to identify drivers of habitat change and fine-scale habitat features for ice seals and walruses

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Alaska's Bering Strait region is undergoing considerable changes in seasonal sea ice quantity and quality, as well as dramatic increases in shipping due to reductions in Arctic summer sea ice cover. In this study we document indigenous perspectives on how these changes may affect ice seals and walruses, as these species provide food security and cultural identity to area communities. We conducted semi-structured interviews and mapping focus groups with 82 elders and expert hunters in order to identify important seal and walrus habitat areas, fine-scale habitat characteristics, and drivers of change in habitat areas. This has led to the identification of four locally-recognized drivers of habitat change: ice conditions, prey species, disturbance, and pollution. Additionally, we have documented a number of landscape and cultural features that are frequently associated with ice seal or walrus concentrations, including capes, islands, river mouths, estuaries, old villages, and seasonal camp sites. Some project participants have also articulated a theory of marine mammal adaptive capacity, based on long-term observations, that provides a more optimistic prediction of marine mammal response to climate change. These indigenous theories of habitat and habitat change have generated policy recommendations for the protection of ice seals and walruses.

Lewis Point, a seasonal subsistence fish camp in transition: negotiations in a mixed cash/subsistence economy 1980-2011

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Since the 1980s on the Nushagak River of Southwest Alaska, summer relocation of New Stuyahok residents to the Lewis Point subsistence salmon fish camp has been declining. From the 1960s to the 1980s, nearly every household moved to the camp seasonally as a strategy to coordinate overlapping subsistence and commercial fishing opportunities. Making careful negotiations of time and place, the Yup'ik fishers of Lewis Point have expanded fishing strategies in harvest location, timing, and methods to accommodate increasing summer economic opportunities in the community of New Stuyahok and decreasing opportunities in the commercial salmon fishery of Bristol Bay, located just downriver from the Lewis Point fish camp. Shifting patterns of use of the fish camp have accompanied advancements in boating technology since the 1980s, allowing for faster river travel on the 80 mile trip between the community and the fish camp. Two summers of ethnographic research reveal ongoing strategies of a community of Yup'ik fishers in their efforts to coordinate subsistence fishing and wage-employment in the face of environmental, economic, technological, social, and political change. These findings highlight the importance of integrated and holistic management practices that accommodate coordinated subsistence and commercial efforts.

Speakers: Bering Sea and Aleutian Islands
Climate & Oceanography

Ice-ocean interactions in the Bering Sea: observations and model simulations

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The eastern Bering Sea shelf hosts a seasonal sea-ice presence with most of the ice produced in polynyas. Northerly and northeasterly winds during winter and spring, and topography define a persistent winter "conveyor belt" of ice floe advection over the shelf. The formation and melting of sea ice modifies the water column. For instance, sea ice both cools the water column and, since ice is less saline than seawater, transports fresh water southward. The characteristics of sea ice and melt water at the edge of the ice field depend on location, ice origin, and atmospheric forcing. For example, ice from Norton Sound generally reaches the ice edge via a corridor passing between St. Matthew and Nunivak Islands, while ice on the southern middle shelf is composed less of this northern ice, and more of ice formed near Nunivak Island. We use Modis True-color satellite images to track ice-floe movement and AMSR to calculate areal ice concentrations. We also use data from the long-term moorings sites (M2, M4, M5, M8) on the middle shelf to examine how the water column responds to ice melt. The water column at each mooring is well-mixed under the ice, but other water properties respond differently to the arrival and retreat of ice depending upon location. For instance, at the two southern sites ice rapidly cools the water column by ~2°C, while at the northern site the water is already near freezing when ice arrives and there is little temperature response. Variations in melt have important implications for salinity. For instance, salinity remains largely unchanged at the northern mooring, but at the two southern moorings salinity freshens in days by as much as 0.6 psu. Melting ice can also be a source of nutrients, especially in the south. Ice retreat can also modify the water column. The observational data are compared with output from NCAR CESM models to better understand ice-ocean interactions. Model characteristics of cooling correlate well with observations, though discrepancies in the depth of mixing are evident.

Geostrophic circulation and water masses of the SE Bering Sea shelf

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Previous investigations of the SE Bering Sea shelf have included closely spaced CTD casts, but along isolated sections that were too far apart to draw detailed inferences about water properties and flow between sections. We present measurements from summer 2008-2010 on a 37-km x 37-km x 1-m grid of approximately 300 casts covering most of the shelf during NOAA/AFSC's bottom trawl surveys. This gives the first comprehensive 3-D view of the temperature, salinity and density fields including the Cold Pool (temperature < 2 C). Geostrophic velocity vectors from the gridded observations reveal the thermohaline circulation. Results show consistent pole-ward flow of warmer water along the outer shelf, above the 100-m isobath, from the Pribilof Islands, across the shelf, past St. Matthew Island and into Russian waters. In summer 2008, there was clockwise geostrophic circulation around St. Matthew Island owing to a lens of freshwater there. That same summer, Mordy et al. (2012, doi:10.1016/j.dsr2.2012.02.012) noticed a sharp decrease in the nutrient content of the lower layer along the 70-m transect south of St. Matthew Island. Motivated to understand this, we examined the T-S (temperature-salinity) diagrams from over 2000 CTD casts collected during 13 cruises supported by the BEST-BSIERP Bering Sea Project. We identified 3 formerly known water masses (Anadyr Water, Bering Shelf Water and Alaska Coastal Water) and one new water mass (Rejected Brine Water). As the name implies, the Rejected Brine Water mass encompasses water whose T-S properties are formed by cooling to the freezing point, sea ice formation, brine rejection and ensuing salinity increase. Water-mass maps reveal Anadyr Water on the outer shelf, Bering Shelf Water on the middle shelf and Alaska Coastal Water on the inner shelf south of 58 °N. North of there, Rejected Brine Water occupies the middle shelf, forming the core of the Cold Pool. The map at 50-m depth in 2008 shows that the region of nutrient decrease along the 70-m isobath was due to low-nutrient Alaska Coastal Water displacing Bering Shelf Water. Thus the ocean physics helps to explain the distribution of nutrients used by phytoplankton at the base of the marine ecosystem.

Integrated assessment of the carbon budget in the southeastern Bering Sea: from the atmosphere to the sediment

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The southeastern Bering Sea Shelf is one of the ocean′s most productive ecosystems in the global ocean and sustains more than half of the total US fish landings annually. Over the last several decades, the character of the Bering Sea shelf ecosystem has undergone a dramatic shift, causing notable increases in the dominance of temperate features coupled to the decline of arctic species and decreases in the abundance of commercially important organisms. Recently, a number of individual carbon parameters have been directly measured, creating a unique opportunity for synthesis and the development of the first coastal carbon budget for the region in more than two decades. Here, we present a complete carbon budget for the Bering Sea Shelf extending from the Aleutian Archipelago to St. Lawrence Island, and across the shelf from the near-shore to the shelf break. In addition to local biogeochemical modification, we include influences of flow through the major Aleutian Passes, coastal river discharge, and interactions with the adjacent Bering Sea Basin. Through estimates of air-sea gas exchange, photosynthetic primary production, net community production, export production and benthic carbon consumption, we quantify lateral transport of carbon on both a regional and shelf-wide scale, with an emphasis on the transport of carbon across the shelf break and past St. Lawrence Island to the northern shelf. This budget also provides a baseline for the measurement of expected continuing environmental change.

Speakers: Bering Sea and Aleutian Islands

Lower Trophic Levels

Spring and fall phytoplankton blooms in a productive subarctic ecosystem, the eastern Bering Sea, during 1995-2011

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The timing and magnitude of primary production in subarctic ecosystems often determines the amount of energy that travels through each trophic pathway. The eastern Bering Sea is dominated by a broad continental shelf (~500 km wide). A large part is ice-covered during winter with the southern extent varying >100 km annually. Four oceanographic moorings have been deployed along the 70-m depth contour in the eastern Bering Sea with the more southern locations sampled regularly since 1995 and the more northern locations since 2004. Fluorescence data from the four moorings provide 37 realizations of a spring bloom and 40 realizations of a fall bloom. We found that in the southeastern and northern Bering Sea: 1) if ice was present after mid-March, a bloom occurred affiliated with ice retreat; and 2) otherwise a spring bloom usually occurred in late May. A fall bloom also commonly occurred in the northern and southeastern Bering Sea; the bloom occurred in late September and its timing was not affected by storm or fall overturn timing. The magnitudes of the spring and fall blooms are related, implying that a common factor influences spring and fall primary production. The length of time between the spring and fall blooms varied between four to six months depending on year and location. The length of time may affect secondary production. For example, large crustacean zooplankton that overwinter on the eastern Bering Sea shelf (e.g., *Calanus marshallae* and *Thysanoessa raschii*) likely benefit in years when ice is present after March 15, but ice retreat is relatively early.

Speakers: Bering Sea and Aleutian Islands
Lower Trophic Levels

On-shelf transport of oceanic mesozooplankton populations in the Eastern Bering Sea

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The Eastern Bering Sea shelf is divided into distinct hydrographic domains by structural fronts. Despite the frontal obstructions to cross shelf transport, each year large oceanic copepods, primarily Neocalanus spp., are known to dominate the biomass of the outer-shelf zooplankton communities and in some years are advected into the middle shelf domain. Using ROMS (Regional Ocean Modeling System) coupled to a particle tracking algorithm to represent ontogenetic vertical migration behavior of Neocalanus, we explored the mechanisms, timing and location of onshore transport of oceanic zooplankton onto the eastern Bering Sea shelf from source locations along the Gulf of Alaska and Bering Sea shelf breaks under a variety of environmental conditions. While the percentage of overwintering zooplankton transported onto the shelf may not vary significantly year to year the timing of on-shelf transport and distribution of oceanic zooplankton on the shelf can vary substantially between years. Wind is the primary factor controlling inter-annual variability in on-shelf transport of Neocalanus. Transport across the northern and southern shelf responds in opposite directions to inter-annual differences in wind forcing. Meridonal winds over the Bering Sea are more important than zonal winds in driving on-shelf float transport. Southerly wind enhances on-shelf transport of oceanic zooplankton on the southeastern shelf while suppressing on-shelf transport over the northern shelf. Conversely, northerly wind suppresses transport onto the southern shelf but promote strong transport onto the northern shelf. Transport of zooplankton onto the shelf can be very episodic, reflecting the short duration of winds promoting on-shelf transport. Relatively short (days to weeks) periods of southerly wind between January and June can substantially increase the number of zooplankton transported onto the shelf. Despite inter-annual differences in the magnitude of on-shelf transport, the relative importance of different source areas in supplying oceanic zooplankton to the Bering Sea shelf did not vary much year to year.

Climate-mediated changes in zooplankton community structure for the eastern Bering Sea

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Zooplankton samples were collected on BASIS fisheries oceanography surveys during August – September 2003-2009 in the eastern Bering Sea. We evaluated variations in zooplankton community composition and total abundances for warm vs. cold years across oceanographic shelf domains in the southern and northern Bering Sea. Initial results indicate that large taxa were more abundant and small taxa less abundant in warm (2003-2005) than in cold (2006-2009) years in the south. In contrast, total abundances of large and small taxa did not show distinct warm and cold year variations in the north. For community composition, the most significant differences between warm and cold years were observed in the southern Middle and Inner domains for large and small taxa. Significant differences between warm and cold years were also found for large taxa in the southern Outer and northern Middle domains. Large zooplankton that contributed the most (greater than 10%) to dissimilarity in community composition between warm and cold years for at least one oceanographic domain include Caridea and Cnidaria (higher in warm years), appendicularia (higher in warm years in southern Middle and higher in cold years in northern Middle), the pteropod *Limacina helicina*, the chaetognath *Parasagitta elegens* and *Calanus* spp. copepods (all higher in cold years). Small zooplankton taxa that showed greatest dissimilarity between regimes include the copepod *Oithona similis*, bivalve, Echinoderm, and Polychaete larvae (higher warm years), and *Acartia* spp. copepods (higher in cold years). Environmental factors that explain the largest amount of variability in zooplankton community composition include temperature and salinity below the mixed layer depth, and temperature above the mixed layer depth.

Speakers: Bering Sea and Aleutian Islands
Fish and Fish Habitat

The influence of a changing climate in management: a Management Strategy Evaluation for the fishery for snow crab in the eastern Bering Sea

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Shifts in the climate of the eastern Bering Sea (EBS) have most recently occurred in 1977 and 1989. These shifts have been shown to affect recruitment of commercial species in the EBS, and the 1989 shift appears to have influenced snow crab recruitment. A model for snow crab recruitment is presented in which control of recruitment dynamics shifts from female spawning biomass to environmental effects with break points defined by regime shifts. This recruitment model is coupled to predictions of climate indices from the Intergovernmental Panel on Climate Change to provide a potential future recruitment scenario. Management Strategy Evaluation is performed to compare the harvest control rule currently used to a rule that allows the target biomass to change with climate regime and hence expectations about recruitment. Regime based harvest control rules increase long-term yield but also increase the probability of overfishing compared to the current harvest control rule when population dynamics are regime based.

Evolving perceptions of forage fish distributions in the SE Bering Sea

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Distributions of eastern Bering Sea capelin (*Mallotus villosus*), age-0 Pacific cod (*Gadus macrocephalus*), and age-0 walleye pollock (*Theragra chalcogramma*) have been characterized over the several decades using data from non-target trawl surveys and/or in limited geographic areas. We examine whether recent acoustic-trawl characterizations of distributions, linkages to oceanographic conditions, and diel behavior are consistent with reported patterns in the literature and, if not, whether differences can be attributed to annual climate conditions and/or gear constraints. Data for this analysis were collected during the 2008-2010 late-summer regional BASIS survey and a high-resolution survey, nested within the BASIS grid, in 2010. Previous acoustic data were also available from the 2006 and 2007 BASIS surveys. Our analysis suggested that forage fish distributions in 2006-2010 often had broad spatial patterns but that patterns could be discontinuous between and among gridded trawl stations. The occurrence of all species, but particularly age-0 pollock, below the sampling depth of surface trawls in 2009 and 2010 suggests that fixed deployment gears may not capture the overall distribution of a species. Both oceanographic and annual variables (e.g. wind, climate) were predictors of forage fish presence and/or density, with some relationships from this analysis supporting previously-published findings. Finally, we evaluate how the cumulative understanding of forage fish distributions should inform biological models of the Bering Sea ecosystem and potential survey development.

Ecology of Pacific halibut (*Hippoglossus stenolepis*) and Greenland halibut (*Reinhardtius hippoglossoides*) in canyon and slope habitats of the eastern Bering Sea

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We examined differences in canyon and slope habitat utilization, and spawning to nursery area connectivity for the deep sea spawning flatfishes Pacific halibut (*Hippoglossus stenolepis*) and Greenland halibut (*Reinhardtius hippoglossoides*) in the eastern Bering Sea using diverse and complimentary approaches. First distribution and abundance of adults, larvae and juveniles were seasonally assessed using field surveys and historical data from the NOAA/Alaska Fisheries Science Center and the International Pacific Halibut Commission. Second, coupled hydrodynamic and individual-based models were used to evaluate where and when eggs and larvae crossed from off-slope spawning locations to the continental shelf, and to determine critical settlement and nursery habitat for offspring. Finally, statistical models were used to evaluate the impact of climate variability on transport and settlement success. Results indicate that, during non-spawning periods, Greenland halibut adults tend to be more abundant along the continental slope, while the abundance of adult Pacific halibut is greater in undersea canyons. However, during the spawning season no differences in habitat use were found for either species. Oceanographic modeling results indicate that connectivity of Greenland halibut larvae between the slope and the shelf primarily occurs via undersea canyons (Pribilof, Zhemchug) to the north, while Pacific halibut larvae connect via southerly canyons (Pribilof, Bering). Statistical models showed spatial and temporal variability in connectivity and settlement success that were related to broad-scale climate indices such as the Arctic Oscillation (AO), Pacific Decadal Oscillation (PDO), and North Pacific Index (NPI). Results indicate that climate variability may potentially have significant impacts on the distribution, abundance, connectivity and habitat use of these two commercially-important deep-sea flatfishes.

The influence of climate change and predation on biological reference points estimated from multispecies and single species stock assessment models

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Multispecies stock-assessment models (MSM) are increasingly used to quantify the indirect effects of harvest on species populations and evaluate management trade-offs for fisheries that target several species in a food-web. MSM simultaneously runs age-structured stock assessment models and links the models by conditioning annual mortality rates on predator abundances (i.e., predation mortality). Predation mortality (based on age-specific diet data) is typically modeled as a series of functional responses ranging in complexity from linear models to non-linear interactions. Since MSM can capture critical thresholds that characterize many ecological interactions, it provides a statistical method for evaluating direct and indirect effects of harvest on multiple species. Yet, MSM conditional mortality rates have confounded previous efforts to derive multi-species biological reference points (e.g., maximum sustainable yield; MBRPs) and have proved challenging when trying to employ MSM for tactical decision-making. Further, previous approaches have used static predator rations to predict species interactions and were therefore unable to capture climatic driven changes in predation and attendant fishing impacts. In this study, we modified an existing MSM for three species of fish from the Bering Sea (walleye pollock, Pacific cod, and arrowtooth flounder) to incorporate temperature dependent predator rations estimated using Wisconsin bioenergetics models (i.e., MSMt). We additionally used projections of the model to derive MBRPs for various harvest control rule approaches. As part of the Alaskan NOAA Integrated Ecosystem Assessment we have collaborated with the North Pacific Fisheries Management Council to use MSMt to examine the effects of MBRPs on specific fishing management strategies. Initial results indicate that MSMt estimates of recruitment are higher than those from analogous single species models, whereas harvestable biomass is lower. Climate influences the energetic demand of predators and results in variable MBRPs under different climate scenarios. MBRPs are also strongly influenced by harvest rates of predator populations. When fishing pressure on predators is attenuated, predation mortality increases and reduces unfished biomass of prey species. Our results demonstrate that prey species populations are strongly influenced by the interacting effects of climate and predator harvest rates, underscoring the importance of considering the interaction of both factors in fisheries management.

Hydrographic structure and the distribution of seabird communities across the southeastern Bering Sea shelf

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One of the hypotheses of the Bering Sea Project is that climate-ocean changes will change the distribution or structure of the eastern Bering Sea food webs, and apex predators will alter their foraging distribution in response. We tested the hypothesis that the distribution of seabird communities across the southeastern Bering Sea shelf reflects the underlying hydrography and marine ecosystem structure. Over the shelf, in summer, there are four hydrographic domains: the well-mixed Inner or Coastal Domain (< 50 m) the well-stratified Middle Domain (50 m - 100 m), the three layer Outer Domain (100 m - 200), and the Shelf Slope Domain (200 m - 1000 m). To examine seabird communities with respect to these domains, we quantified the cross-shelf distribution of species with respect to water depth, and clustered species with similar depth-use-distributions using a 35-year database. We then mapped these clusters against the hydrography. There were considerable differences among seabird species in the water depths over which they were observed. Multivariate regression tree analysis revealed four main species-depth groups in summer: Group 1, an inshore, shallow water group, conformed roughly to the Inner Domain; Group 2 occupied the Middle Domain, though only out to about the 80 m isobath; Group 3 extended from the 70 m isobath to about the 180 m isobath; and Group 4 occurred over the shelf slope and deeper waters. In winter, spring, and fall, wind mixing and lower temperatures lead to a breakdown of the stratification which defines the hydrographic domains during summer. This allows us to evaluate the importance of the hydrographic structure on the seabird community. The seabird groupings were similar in spring and fall; in winter (1 March -15 April) there was no inshore group, and the species composition of clusters differed considerably from the other three seasons. Our results show that seabird distributions are sensitive to domain boundaries and that seabirds will shift their distributions seasonally in accord with shifting ecosystem structure.

Speakers: Bering Sea and Aleutian Islands
Seabirds

Do albatrosses use molting areas in the Aleutian Islands? Important bird areas within productive fishing grounds

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

Speakers: Bering Sea and Aleutian Islands
Seabirds

Year-round spatial and temporal distribution of a small, diving seabird, the Crested Auklet (*Aethia cristatella*), originating from a breeding site at Buldir Island, Aleutian Islands

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Year-round seabird ecology and behaviour is poorly understood due to difficulties associated with monitoring their at-sea distribution during the non-breeding season in often harsh and remote environments. However, the development of increasingly small and light remote-sensing devices has permitted tracking of bird movement across large oceanic distances for long periods of time. To examine the movement of Crested Auklets (*Aethia cristatella*), a small, diving seabird, we deployed miniaturized, tarsus-mounted geolocators (Lotek LAT2900, 2 g, <1% body mass) on 31 individuals in 2011, from their breeding sites at Buldir Island, Aleutian Islands, AK. We recovered 10 geolocators (32% return) in 2012, with data revealing, for the first time, migration routes and important wintering areas for Crested Auklets breeding at a western Aleutian Island. We have found that immediately following the breeding season, tagged individuals migrated c.1400 km north to the Gulf of Anadyr, and Bering Strait. In December, they travelled c.3400 km directly south-west to productive waters off the Kuril Islands and Hokkaido, Japan, finally moving c.2300 km east to Buldir Island in April - an incredible and unexpected triangular, long-distance migration pattern. Prior to our study, knowledge of Crested Auklet wintering areas was limited to opportunistic at-sea ship surveys, indicating that large numbers of birds winter in euphausiid-rich areas in large Aleutian passes. Our novel research has provided encouraging preliminary results for the feasibility of tracking small, heavy wing-loaded auks using archival-light geolocators, and has potentially identified ecologically important areas for planktivorous seabirds breeding in the Western Aleutian chain of Alaska.

Speakers: Bering Sea and Aleutian Islands
Marine Mammals

Some maternal Steller sea lion diets elevate fetal mercury concentrations in the western Aleutian Island area of decline

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One hypothesis for the lack of recovery of endangered Steller sea lions (SSLs, Eumetopias jubatus) in Alaska is low natality. Although there is no direct evidence mercury contamination causes adverse effect in SSLs, it is known high mercury exposure is neurotoxic to humans and other piscivorous mammals and can impact reproduction. Young pups have higher total mercury concentrations ([THg]) in hair than older SSLs, suggesting pups are exposed to mercury in utero during gestation when lanugo (natal pelage) is grown. With limited direct information regarding the foraging habits of adult females in the western Aleutians, we utilized patterns of δ13C and δ15N deposited in the vibrissae (or whiskers) of young pups to help us understand how diet variations between gestating females might impact mercury exposure during this critical period of fetal development. Hair and a vibrissa were collected from 22 SSL pups (newborn to 6 weeks old) on their natal rookery at Agattu Island, in the western Aleutian Islands, Alaska. Hair was washed, freeze-dried and analyzed on a direct mercury analyzer (Milestone DMA-80). We measured δ13C and δ15N in approximately 0.1 cm sections selected every 0.5 cm along the length of the vibrissa from the tip (earliest in utero) to the root (present nursing signature). Five to 8 sections estimated to represent the growth during late gestation were selected for each pup to establish a mean δ13C and δ15N of the fetal vibrissa tissue during that period. Hair [THg] was highly variable among pups, ranging from 3.7 to 63.9 μg/g dwt. The highest [THg] concentrations were above risk thresholds for other mammals. Pups born with the highest [THg] in their hair (above 40 μg/g) showed significantly higher δ15N in vibrissa tissue grown during late gestation ($F_{2,25}=8.61$, $p=0.0019$) suggesting that their mothers may have incorporated higher trophic level fish into their diet. The wide distribution of both δ13C and δ15N seen in late gestation vibrissae segments of these pups illustrates the diverse nature of the isotopic signature of the diet of adult females, whether that be driven by trophic level of the prey species, the geographic location of foraging, or both.

Speakers: Bering Sea and Aleutian Islands
Marine Mammals

Winter site fidelity of bearded seals in the Bering Sea

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Six bearded seals (*Erignathus barbatus*) were tagged with small satellite-tracking transmitters attached to their hind-flippers in Kotzebue Sound, Alaska, during late June or early July of 2009 (three males) and 2011 (two females and one male). After spending the months of August – December in the Chukchi or Beaufort seas, the three individuals tagged in 2009 migrated south to the Bering Sea where they spent the months of January – April, 2010. Their wintering areas were typically restricted to a radius of about 40 km. Two individuals wintered near each other in the upper reaches of Norton Sound, while the other wintered near the sea ice edge in the vicinity of St. Matthew Island. During the winter of 2011, all three individuals again used the same spaces they had occupied in 2010. In the winter of 2012, the pattern was repeated, and at the same time, the three seals tagged in 2011 took up their (unique) wintering locations in the Bering Sea. We predict that in the winter of 2013, the latter three seals will return to the same areas used in 2012, confirming a pattern that suggests strong philopatry in this species. The two sub-adults tagged in 2009 are now, after three years have elapsed, likely to be full adults; Bering Sea bearded seal males, at least, exhibit strong winter site fidelity, apparently establishing their preferred sites even as sub-adults. This is the first direct confirmation of site fidelity in bearded seals, and it is consistent with inference drawn from acoustic recordings in successive years and with genetic studies that have found population structure in this species. Strong fidelity to wintering sites may limit bearded seals′ capacity to adapt to shifting ice distributions in a warming Arctic climate.

Speakers: Bering Sea and Aleutian Islands
Marine Mammals

Soviet catches of whales in the North Pacific: revised totals

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The USSR conducted a global campaign of illegal whaling beginning in 1948. Catch records for Soviet operations in the Antarctic have been largely corrected with true data, but major gaps have remained for the North Pacific, including Alaska waters. Here, using newly discovered whaling industry reports, we provide corrected figures for Soviet catches in this ocean. During the period 1948-1979, a minimum of 190,183 whales were killed by the USSR in the North Pacific (195,783 if one includes an estimate for sperm whales taken in years for which there are no true data); of these, only 169,638 were reported to the IWC, a difference of 20,568 whales (26,168 including the sperm whale estimate). Figures were falsified for 8 of 12 hunted species, with some catches over-reported to camouflage takes of illegal species. Revised catch totals are as follows: blue whale - 1,621 caught vs. 858 reported; fin whale - 14,167 vs. 15,445; humpback whale - 7,3 34 vs. 4,680; sperm whale - 153,686 vs. 132,505; sei whale - 7,698 vs. 11,363; North Pacific right whale - 681 vs. 11; bowhead whale - 145 vs. 0; gray whale - 172 vs. 24. Bryde′s, minke, killer and Baird′s beaked whale catches were reported correctly. Of all the hunted species, sperm and North Pacific right whales were the hardest hit; details of catches in Alaskan waters of the latter species will be discussed. Major falsifications for sperm whales involved figures for both total catch and sex ratio. Not "Of all the hunted species, sperm and North Pacific right whales were the hardest hit; details of catches in Alaskan waters of the latter species from Alaskan waters."

Killer whale (*Orcinus orca*) depredation effects on catch rates of six groundfish species: Implications for commercial longline fisheries in Alaska

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Killer whale (*Orcinus orca*) depredation occurs when whales damage or remove fish caught on fishing gear. Killer whales in Alaska primarily depredate on sablefish (*Anoplopoma fimbria*) and Pacific halibut (*Hippoglossus stenolepis*) demersal longline fisheries. Killer whale depredation results in catch reductions, increased fishery operating costs and can reduce the accuracy of fish abundance indices. These interactions also have negative consequences for the whales in increased risk of entanglement, vessel strikes and altered foraging strategies. This study uses National Marine Fisheries Service Longline Survey data from 1998-2011 to explore spatial and temporal trends in killer whale depredation, and to quantify the effect of killer whale depredation on catches of six commercially harvested groundfish within three management areas in Alaska; the Bering Sea, Aleutian Islands and Western Gulf of Alaska. Using a Generalized Linear Modeling approach, we found that when killer whales were present during survey gear retrieval, whales removed an estimated 54%-72% of sablefish, 41%-84% of arrowtooth flounder (*Atheresthes stomias*), 39%-49% of Pacific halibut and 73% (Bering Sea only) Greenland turbot (*Reinhardtius hippoglossoides*). Overall catches of depredated groundfish in all three management areas were estimated to be lower by 9% to 28% due to killer whale depredation ($p<0.05$). Effects on Pacific cod (*Gadus macrocephalus*) and shortspine thornyhead (*Sebastolobus alascanus*) catches were not significant ($p>0.05$). These results provide insight into the potential impacts of killer whale depredation on fish stock abundance indices and commercially important fisheries in Alaska and will inform future research on apex predator-fisheries interactions.

Speakers: Gulf of Alaska
Ecosystem Perspectives

The Gulf of Alaska in 2011: The view from GOAIERP

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Over 40 scientists are currently working on the large-scale interdisciplinary ecosystem study known as the Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP). The goal of this study is to use coordinated investigations at multiple levels (field work, laboratory analyses, modeling) to better understand the dynamics of the GOA ecosystem and the forces that influence the survival of juvenile fishes. The project duration is 2010-2015, with the major field activities occurring in 2011 and 2013. These activities include seasonal fish and oceanography surveys (spring, summer, fall) in the eastern and western GOA. The surveys comprise a grid of offshore stations and smaller-scale research at eleven inshore sites. The work completed in 2011 provides an illustration of the coordinated nature of the program, and suggests that 2011 was an anomalously low-productivity year in the GOA. The El Niño- Southern Oscillation, which appears to strongly influence GOA climate and hydrography, was negative in 2011. Satellite and ship-based data indicate that the spring bloom was late, and that overall phytoplankton production was low relative to the mean level from 1998-2011. In the offshore surveys, catches of age-zero walleye pollock and Pacific cod were almost nonexistent and juveniles of several species of rockfish were in low abundance relative to observations from 2010 and earlier. Several GOA seabird populations suffered reproductive failures in 2011, and seabirds were largely absent from many inshore areas where they had been observed in 2010. The amount of fish-related acoustic backscatter from inshore acoustic surveys appeared low, although this result will need to be compared to 2010 and 2013 data for proper interpretation. Limited field work conducted in 2010 and 2012, as well as the full field effort in 2013, will provide essential context for the 2011 observations.

Speakers: Gulf of Alaska
Ecosystem Perspectives

The effects of temperature and predator densities on the consumption of walleye pollock (*Theragra chalcogramma*) in three groundfish predators in the Gulf of Alaska

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Multiple approaches have been taken to model Alaskan fisheries in a multispecies framework. However, most previous efforts in modeling interspecies interactions have made important assumptions regarding predator-prey dynamics. Commonly, a predator's functional response is assumed to depend on prey density and predator size alone. Ecological evidence suggests that environmental factors, such as temperature, affect interspecies dynamics by altering behavior and activity of both predators and prey. Furthermore, a predator's behavior has been shown to be affected by the presence of other predatory species both competitively and synergistically. Using a time series of trawl and stomach data we investigated the effect of predator length, prey availability, temperature and other predators' densities on consumption of walleye pollock by sablefish, Pacific cod and Pacific halibut in the Gulf of Alaska (GOA). We took an information-theoretic approach to multiple regressions to determine which factors influence both presence and proportion of weight in an individual's diet of walleye pollock for data at the entire GOA and regional scale. Temperature was found to be negatively influencing consumption of walleye pollock by both Pacific cod and Pacific halibut. Pacific halibut were observed to be negatively influencing consumption by both Pacific cod and sablefish, whereas Pacific cod were found to facilitate predation of walleye pollock by sablefish. Of length and availability of prey, only length was consistently found to be influencing consumption, with larger predators preying on more walleye pollock. Prey density was found to be a poor predictor of consumption for these species in this system, and more complex regression models that included environmental factors were found to be much more likely given the data than those based on predator length and walleye pollock density alone. In general, patterns were consistent across diet metrics and spatial areas, with some exception. These results indicate that predator-prey dynamics in this system are complex and that including temperature and predator-predator interactions in multispecies modeling efforts may be warranted.

New techniques for controlling the spread of the tunicate, *Didemnum vexillum* in Alaska

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The colonial tunicate, *Didemnum vexillum* (Kott, 2002) has invaded marine habitats worldwide, covering large areas of both manmade and natural substrates and altering marine ecosystems. To date, it is known from only a single locality in Alaska, an old aquaculture farm in Whiting Harbor, Sitka. Several possible methods of eradicating the tunicate were tested over different time scales in a series of 4 trials, initially in Half Moon Bay, California and then at the site of the infestation in Sitka, Alaska. Treatments included: freshwater, bleach (0.5% and 1%), low dissolved oxygen (< 0.8 mg/liter), hypersalinity (60 ppt for long time scales and 80 ppt for very short time scales), desiccation, acetic acid (4% and 10%), and cement dust (1%). Effects of bleach were variable. Low dissolved oxygen, desiccation, short doses of salt (80 ppt) and freshwater treatments had little or no effect over the time scales examined, while those using acetic acid, hypersalinity (60 ppt) and cement dust showed promise for eradication of *D. vexillum*, resulting in nearly 100% mortality over the longest time scales examined. We discuss the possible use of these treatments for control of *D. vexillum* fouling of aquaculture and fishing gear, for fouling on aquaculture species such as mussels and oysters, and finally, their potential for large scale eradication of this tunicate from the seafloor in Whiting Harbor.

Speakers: Gulf of Alaska
Humans

Empirical measures for Aaskan fishing communities

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We have developed a set of empirical measures of Alaskan fishing communities for the years 1980-2010 using publicly available annual data maintained by the Alaska Commercial Fisheries Entry Commission. These include both total and per-capita measures of permit holdings, fishery participation, and gross earnings; concentration of permit holdings, participation and earnings; duration of permit tenure; new fishery entrants; and a variety of measures of fleet characteristics. Together, these empirical measures allow a systematic comparison of long-term trends among all Alaska fishing communities—in contrast to most previous analyses which have focused on specific measures or specific communities. In this presentation we describe these measures and discuss trends of particular interest. These include (a) wide variation in fishery earnings over time and between communities, reflecting trends in prices, resource abundance, and permit holdings and fishery participation; (b) a long-term decline in earnings and participation in many smaller communities; and (c) a long-term decline in the number of new fishery entrants in most communities. These types of empirical measures can help in systematically monitoring the extent to which fishery management is providing for sustained participation of fishing communities, as called for by National Standard 8 of the Magnuson-Stevens Act.

Sensemaking at sea: Organizing for self-management at the front line of Alaska's commercial fisheries

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Robert Chia, scholar of management and organizations, wrote, "Managing is firstly and fundamentally the task of becoming aware, attending to, sorting out, and prioritizing an inherently messy, fluxing and chaotic world of competing demands that are placed on a manager's attention. It is creating order out of chaos. It is an art, not a science. Active perceptual organization and the astute allocation of attention is a central feature of the managerial task" (2005: 1092). This exploratory study uses theory from the field of management and organizational studies to look at how fishing captains, using the Central Gulf of Alaska (CGOA) trawl fleet as a case study, manage their messy, fluxing, and chaotic world with the goal of creating order that allows them to move closer to maximizing their potential. The motivation for this study stems from the global trend of shifting fisheries management responsibilities from government agencies to fisheries practitioners, primarily in the form of quota share systems. Thus, this study explores the questions, How do captains make sense of their dynamic and complex contexts? What are the parts from which such processes are constructed? What factors constrain and enable their ability to make sense of their contexts and move toward their goals (i.e., self-manage)? To answer these questions, this study draws from the author's dissertation research, which encompassed observation of the CGOA trawl fleet over two winter pollock and cod seasons (nine months total), eight days aboard four trawl vessels engaged in both fishing and cooperative research, and 27 semi-structured interviews of CGOA trawl captains. These data were analyzed with qualitative analysis software (NVivo), using an approach that maximizes theory development from the ground-up. The focus of the talk will be a preliminary model of front-line fisheries self-management in which the primary goal is bycatch control and maximization of target catch. The talk will conclude with policy recommendations for fostering functional front-line self-organizing processes, including how those processes can better articulate with external participants who rely on the same ecological system for their economic well-being.
Chia, R. (2005). Organization Studies, 26(7).

Speakers: Gulf of Alaska
Humans

Between Pacific tides: Engaging the community of Sitka in science through time

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In 2011, the Sitka Sound Science Center began a community engagement project re-establishing intertidal surveys from 1932 and 1996 in Sitka Sound. The authors of *Between Pacific Tides*, Jack Calvin and Edward Ricketts, established the sites when they studied littoral biology 80 years ago, from Puget Sound to Sitka, the home of Calvin. During these surveys, visionary ecological paradigms were explored. These seminal thinkers formulated a view of ecological holism, the interrelatedness of animals to each other and their environment. They were early proponents of ecosystem management. In 1996, Dr. Molly Ahlgren began using Sage Rock beach as an outdoor classroom, conducting intertidal surveys until her untimely death in 2004. A primary goal of our project was to collect data that would be comparable to these important historic surveys, and thus provide documentation of change (or stability), over time in rocky intertidal communities. For comparison with the Calvin and Ricketts study, three sites were surveyed in 2012 using the Coastal Biodiversity Protocol developed by UC Santa Cruz. To date, historic and recent surveys done on the windward and leeward shores of Kayak Islands have been compared, and examined for patterns of change in species composition. This site was a key survey location used by Ricketts and Calvin in 1932 to describe impacts of wave action upon the intertidal invertebrate communities. At Sage Rock, original Ahlgren plots were sampled, and additional plots were added to better capture the abundance of "key" species. Methods for this long-term monitoring were developed by MARINe (Multi-Agency Rocky Intertidal Network), compatible with Ahlgrens' early surveys. MARINe surveys span the entire west coast, from Mexico to Alaska, allowing for comparisons of patterns seen at Sitka sites to sites coast-wide. This NPRB funded project re-introduced these ideas and this history through community engagement activities that brought Ricketts scholar Dr.Katie Rodger to Sitka for community talks and discussions. Newspaper articles, public radio interviews and stories that ran regionally and statewide helped to engage the community in the subject. The project raised the profile of the importance of collecting baseline data through training community members and developing new agency partnerships.

Along-shelf and cross-shelf flow in the Gulf of Alaska with some implications for primary production

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In 2011 as part of the Gulf of Alaska-Integrated Ecosystem Research Program, 15 moorings were deployed on and recovered from the shelf in the Gulf of Alaska (GOA). Each mooring measured temperature, salinity and currents. In addition, nitrate, fluorescence, oxygen and turbidity were collected at a subset of moorings. These data, together with other historical data, satellite-tracked drifter trajectories, and satellite images are used to describe the basic along-shelf flow in the GOA, locations of enhanced cross-shelf flow, and areas of strong vertical mixing. Each of these has implications for sustained primary production during summer. As expected, coastal currents in both Southeast Alaska and along the Kenai Peninsula revealed a freshening in the wind-mixed layer and spin-up of the currents beginning in August. Measurements from current meters, however, also revealed distinct differences between the well-organized Alaska Coastal Current at Gore Point (the Kenai Peninsula) and the more variable flow along Baranof and Chichagof Islands in Southeast Alaska. On-shelf events were apparent at many locations along the narrow southeastern shelf, while significant on-shelf flow appears limited to canyons and troughs along the broader north-central shelf. Strong vertical mixing occurred at selected locations in both southeastern GOA (Cross Sound and Chatham Strait) and north-central GOA (Kennedy and Stevenson Entrances, and Chiniak Trough). Both on-shelf flow and vertical mixing provide nutrients to the euphotic zone. True-color satellite images show areas of recurrent production throughout the summer in several areas: Icy Point (influenced by Cross Sound), west of the southern tip of Baranof Island (influenced by Chatham Strait), in Shelikof Strait (affected by mixing in Kennedy and Stevenson Entrances) and around Kodiak Island (on-shelf flow in troughs and mixing on shallow banks). The three mooring sites on the southeastern shelf that had fluorometers at 11 m also recorded periods of high (> 10 mg L-1) chlorophyll concentration between May and August, with highest values occurring in June. These three moorings, together with historic time series in north-central GOA, will allow us to more closely examine the mechanisms of prolonged production on these shelves.

Speakers: Gulf of Alaska
Climate & Oceanography

Seasonal surface circulation, temperature, and salinity in Prince William Sound, Alaska

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Conductivity, temperature, and depth (CTD) profiles from 1973 to 2010 were used to construct a seasonal climatology of surface geostrophic circulation, mixed layer depth (MLD), potential energy of mixing, and surface temperature and salinity in Prince William Sound (PWS) and the adjacent Gulf of Alaska. The work by winds was estimated from meteorological buoy data in central PWS and compared to the potential energy of mixing of the upper water column. The potential depth to which winds mix the upper water column was generally consistent with the mixed layer depth. Surface salinity is greatest in winter and least in summer due to the influence of increased freshwater input in summer. It is generally lowest in the northwest and highest in the Gulf of Alaska. The surface temperature is lowest in the winter and highest in the summer when surface heating is greatest, with little spatial variability across the Sound. The MLD is deepest in winter (9-27 m) and shallowest in summer (4-5 m). The surface geostrophic circulation in the central Sound has: a southerly flow in the western central Sound in the winter; a closed, weak anticyclonic cell in spring; a closed, cyclonic cell in the summer; an open, cyclonic circulation in the fall. In the western passages, a southerly flow occurs in spring, summer, and fall. The MLD, surface salinity and temperature, and surface circulation have important implications for oil spill response in PWS and the use of oil dispersants.

Measuring the pulse of the Gulf of Alaska: Oceanographic observations along Seward Line, and in Prince William Sound 1997-2012

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The Seward Line in the northern Gulf of Alaska and stations within western Prince William Sound have been the focus of multidisciplinary sampling for the past 15 years. Here we report on the observations of physical oceanography, nutrients, phytoplankton, and zooplankton over that period, with emphasis on the most recent years. In 2012, May temperatures remained cool – the general pattern observed for the past 5 years (with the exception of 2010). Late summer temperatures were consistent with the September long-term mean. Driven by the cool water temperature, the 2012 spring bloom was delayed, as were spring zooplankton communities, although numerical abundances were closer to the long-term mean, unlike 2011 when abundances were low. Summer temperatures and plankton abundances remained unremarkable in both 2011 and 2012, with the notable exception of the several salp species of warmer-water affinity observed along the Seward Line in those years. The southern copepod *Calanus pacificus* continued to be an obvious component of the summer zooplankton community along the line, a pattern begun in 2005. Implications to higher trophic levels, specifically Prince William Sound hatchery returns, will be discussed.

Speakers: Gulf of Alaska
Lower Trophic Levels

Seasonal and inter-annual patterns of pteropod and larvacean estimates in the coastal Gulf of Alaska

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The Seward Line in the northern Gulf of Alaska has been sampled since 1998. The project's initial focus was on the dominant crustaceous zooplankton. Recent studies suggest that juvenile pink salmon may dominantly feed upon the lesser known larvaceans and the shelled pteropod, *Limacina helicina*. Samples collected between years 2001 to 2011 were analyzed in detail for these two understudied groups. Use of a finer 53 µm mesh net allowed estimation of abundance, biomass and species composition - a task that could not be determined in previous studies for the easily damaged soft-bodied larvaceans. Patterns appear both seasonally and inter-annually between their community composition and abundance. Seasonally, within the larvaceans *Oikopleura labradoriensis* dominates in the spring and *Oikopleura dioica* dominates in the fall. Warm years show higher overall larvacean species diversity and abundance in the summer and fall than cold years. Warm years also favor higher abundance of *L. helicina* in spring, but not necessarily during the fall. Pink salmon survival rates from Prince William Sound are compared to productivity calculations of *L. helicina* and larvaceans.

Fifty shades of green – Phytoplankton time series from the Continuous Plankton Recorder survey

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The Continuous Plankton Recorder has been deployed in the oceanic and shelf regions of the northern Gulf of Alaska since 2000. Although principally a zooplankton sampler, the CPR also retains larger hard-shelled diatoms and dinoflagellates; over 80 phytoplankton taxa have been recorded in this region. Furthermore, a basic index of phytoplankton biomass is available through the Phytoplankton Colour Index (PCI). The seasonal cycles of PCI, diatoms and dinoflagellates are investigated, indicating a bi-modal cycle for diatoms in most (but not all) years and a late summer/fall peak for dinoflagellates. Diatom abundance was greater in warm years and there is some evidence that the seasonal timing of the spring diatom peak was related to spring stratification. Community composition analyses show a trend through time and warmer years have a different phytoplankton composition. The offshore region has a declining trend in diatoms through the time series. In summary, while the CPR does not sample the entire phytoplankton community, valuable insights into the base of the marine food chain can be gained from this time series.

Speakers: Gulf of Alaska
Lower Trophic Levels

Phytoplankton communities and processes in the coastal Gulf of Alaska: Implications of an anomalous year

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A series of cruises in 2011 provided a rare opportunity to study phytoplankton community composition and photosynthetic processes in the eastern coastal Gulf of Alaska (GOA), and to contrast those with conditions in western coastal waters. Ultimately, this portion of the Gulf of Alaska Integrated Ecosystem Research Program will provide insights into lower trophic level processes influencing recruitment success of commercially important groundfish species. Spring of 2011 hosted unusual conditions throughout the coastal GOA. Although bases for comparison are limited, anomalies appeared unusually strong in the east. Phytoplankton biomass was well below bloom levels throughout the usual spring bloom period (May), and continued low for the remainder of the field season except in local embayments. The spring phytoplankton community was mainly composed of very small (<2 µm) cells, including cyanobacteria and pico-eukaryotes; large diatoms were conspicuously absent at most stations. Low biomass and small cells also characterized the microzooplankton (typically the major consumers of phytoplankton in marine systems). Photosynthesis – irradiance experiments conducted throughout the eastern coastal GOA in May yielded strong evidence that phytoplankton were acclimated to low light conditions. Evidence included high photosynthetic efficiencies and frequent observation of photoinhibition at environmental light levels. We are exploring the possible causes of low light availability and its relationship to the anomalous bloom conditions of 2011. Reduced phytoplankton productivity and anomalously low phytoplankton biomass could ramify through the planktonic food web, creating a depauperate prey environment for larval and young-of-the-year fish in the coastal GOA.

Speakers: Gulf of Alaska
Fish and Fish Habitat

Effects of ocean acidification on development of Alaskan crab larvae

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Increased atmospheric levels of carbon dioxide cause an increase in oceanic uptake of this gas, in turn resulting in a drop in the pH of the oceans. In coastal Alaska, several crab populations that once supported commercial or sport fisheries have experienced severe stock declines, and recovery might be impeded by additional challenges such as ocean acidification. The aim of this research is to measure the effects of ocean acidification on the larval development of Tanner crabs (*Chionoecetes bairdi*) and Dungeness crabs (*Metacarcinus magister*). Larvae from females captured in Kachemak Bay, Alaska were raised in flow-through seawater tanks of three different pH levels representing a range expected for the next two centuries in the North Pacific. Larvae were then measured and weighed to estimate growth. The calcium and magnesium content of the larval carapace will also be measured using a laser ablation inductively-coupled plasma mass spectrometer (la ICP-MS). Morphometric measurements suggest some effect of pH on growth and morphology in Tanner crab larvae, while Dungeness crabs showed no significant effects. The reduction in length of some spines and appendages in Tanner crabs may result in enhanced vulnerability to predation and disruption of proper buoyancy control. Differential responses across crab species may reflect increased levels of resistance to changing pH in species that commonly occupy habitats with more natural environmental variability (e.g., Dungeness crab inhabiting intertidal areas). Comparison of impacts of ocean acidification across species thus offers valuable insight on the range of potential responses to pH change among decapod crustaceans.

Getting to the bottom of it: A critical look at stock assessment estimates for red king crab (*Paralithodes camtschaticus*) in southeastern 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 efforts between the ADFG and the commercial fleet by comparing two independent biomass estimates. Specifically, we compare Catch Survey Analysis (CSA) and mark/recapture estimates in eight areas. CSA estimates use ADFG summer survey data, while depletion and mark/recapture estimates were done during the fall/winter on commercial vessels. The two methods produced significantly different estimates with the mark/recapture estimates averaging over 4 times larger than CSA estimates. This dramatic discrepancy can be best explained by crab behavior through changes in distribution, aggregations, and catchability. Our findings re-emphasize how essential a thorough understanding of basic ecology is to fisheries stock assessments.

Speakers: Gulf of Alaska
Fish and Fish Habitat

A field test of an observer-audit approach to improve catch reporting in Alaska: NPRB Project 1017 Alternative catch monitoring of Alaskan groundfish

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The management of fisheries requires that the identity and quantity of fishing mortality be known. In Alaska, both retained and discarded portions of the catch are deducted from quotas set by the North Pacific Fishery Management Council (NPFMC). For catcher vessels, the retained catches used in management are those reported on landing reports (e.g., fish tickets). Estimates of at-sea discards are generated by multiplying the discard rate derived from at-sea observer data and the total retained catch from landing reports. The quality assurance of at-sea catch information is enhanced by the presence of an observer compared to that of landing reports that are not currently monitored for accuracy in species identification by shore-based observers. We conducted a cooperative study to test whether species composition data collected by observers at shoreside processing plants could be used to verify the species composition of the delivery weights of catch that are reported on fish tickets. Observers were deployed to sample the delivered catch from within three fisheries of the Gulf of Alaska. Ratio-estimators were used to generate observer sample-based estimates of delivered catch from each landing. We examined the probability that observer estimates derived from the same population of catch in the landing report under the assumptions that the observer identification was correct and the landing report represents a census without error. Results highlight the utility of using shore-based observers to improve species-identifications on landing reports, especially for species that are currently managed as complexes.

Speakers: Gulf of Alaska
Fish and Fish Habitat

Movement patterns of skates in the Gulf of Alaska and implications for the management of a skate fishery

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Skates are in growing demand worldwide, specifically in European and Asian markets. As part of supplying this demand, the U.S. landings of skates in 2008, mainly from the Atlantic Ocean, was estimated at 65 million pounds, worth US$11 million. However, many Atlantic Ocean skate stocks are declining. In contrast, Alaska has relatively healthy skate stocks but skates can only be retained as non-target catch in federal and state waters of Alaska. Big skates (*Raja binoculata*) are the most frequently landed skate in the Gulf of Alaska and are managed by two management agencies, that each divide the skate non-target catch quota into multiple management areas and assume that big skates do not move among these areas. If a directed skate fishery is to be developed, more ecological data such as movement patterns and habitat use need to be explored. We deployed pop-up archival transmitting (PAT) tags on seven big skates in Prince William Sound, Alaska in July 2011 and set them to pop up in May and June 2012. This was the first instance of an electronic tag being deployed on any skate species in the Pacific Ocean and provided novel data on the movement patterns, temperature and depth utilization of big skates. It also provided a fishery-independent estimate of the connectivity of big skates between management areas. Ecological data such as these are crucial when managing a novel fishery, and are necessary when employing increasingly popular ecosystem-based management.

The spiny issue of ageing spiny dogfish: Historical dogma vs. new methods

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The dogma of using the dorsal fin spine to age spiny dogfish (*Squalus suckleyi*) has been in existence for over 30 years. With these well established methods, the species has a rather long history of published literature on age and growth. However, a problem with this method is that the dorsal fin spine , which protrudes from the body into the environment, is sometimes broken and often worn, thus creating lost or difficult-to-read annuli. Recent research on an Atlantic congener (*Squalus acanthias*) found that a technique using histological staining of vertebrae thin sections made it possible to count annuli, thus eliminating the sources of uncertainty associated with worn spines. However, this vertebral method has yet to be tested in the much longer lived North Pacific spiny dogfish. Our study examines both age structures and compares inter- and intra-reader as well as inter-lab variability in reading annuli to determine which method produces the most precise ages for the North Pacific spiny dogfish. Results suggest a substantial decrease in intra- and inter-reader variability when the vertebrae method is compared to the dorsal fin spine method. Preliminary analyses also show that there are multiple sources of measurement error when using the spine method, sources that do not exist with the vertebrae method, and that inter-reader variance increases substantially more with increasing age with the spine method than with the vertebrae method.

Prince William Sound herring survey program

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In 2009 the Exxon Valdez Oil Spill Trustee Council began funding of a research program on herring in Prince William Sound. The program was made up of ten projects designed to address the identification of juvenile herring rearing bays, measuring factors that limit juvenile herring growth and recruitment, and providing recommendations for future herring restoration and monitoring efforts. The focus was on the first year of life of herring. The work included acoustic and aerial surveys and fishermen led direct capture effort to help identify rearing locations of herring. Oceanographic mooring and surveys were used to describe the oceanographic conditions and food availability. Fish were captured in the fall and spring to examine factors related to their condition and ability to survive through their first winter. These fish were also examined for the prevalence of disease that may further impact their survival. Bird, mammal, and fish surveys examined predation on the juvenile herring. During the three field years of this program the winter water temperatures included years that were warmer than normal, normal, and colder than normal. In August the aerial surveys found age-0 fish widely distributed. Acoustic surveys indicated that the age-0 fish had contracted their range to primarily protected waters at the head of bays by March. Surface water temperatures and salinity are most consistent between bays during the winter. Zooplankton sampling allows us to understand the succession in each of the years and the information is connected to diet analysis we conducted. The condition of age-0 fish were found to be such that it is likely that mortality could reach 90% through the winter. Disease and predation are two other sources of mortality we examined. The parasite *Ichthyophonus* occurred endemically, with annual infection prevalence generally increasing from 0-5% among age-0 cohorts to 33-88% among older fish. During winter, adult walleye pollock and Pacific cod were the primary fish predators, and common murre the most abundant seabird predator of juvenile herring.

Speakers: Gulf of Alaska
Seabirds

Changes in mid-summer abundance of *Brachyramphus* murrelets in Prince William Sound, Alaska, 1989-2012

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The *Brachyramphus* murrelets (*B. marmoratus*; marbled murrelet, and *B. brevirostris*; Kittlitz's murrelet) are small diving seabirds in the alcid family. Both are species of conservation concern. We used boat-based marine bird surveys conducted in Prince William Sound (PWS), Alaska, during July in 12 survey years across 1989-2012, to assess patterns of change in abundance of *Brachyramphus* murrelets. During surveys, members of the genus are not always identified to species, complicating efforts to estimate trends in species abundance. Here, we evaluate two research questions on the combined *Brachyramphus* genus: (1) was there a change in abundance of PWS *Brachyramphus* murrelets across 1989-2012, and (2) did trends in abundance differ among survey transects, and if so were they density-dependent. Density-dependent trends (i.e., changes occurring at different rates in locations with higher or lower mean abundance of murrelets) could indicate that processes underlying population change differentially affected birds in 'marginal habitat' and 'core habitat'. We used generalized linear mixed models to estimate trends in abundance directly from the observed counts, and address both research questions in an integrated analytical framework. To determine whether abundance trends differed among locations, and whether any such differences were density-dependent, we used likelihood ratio tests to evaluate three nested statistical models. The best supported model indicated that murrelet abundance trends have varied among locations in PWS. However, there was no evidence of a density-dependent pattern of change, indicating that rates of change have not differed between 'marginal habitat' and 'core habitat'. For the best supported model, there was strong evidence of a decline in observed abundance of murrelets (Wald Z-test, $p < 2.0*10^{-16}$). We estimate that the mean value of the back-transformed slope parameter, interpreted as the mean annual rate of population change (λ), is 0.940 (95% CI: from 0.934 to 0.946). Over the 23-year survey period, this rate of decline corresponds to a 75.7% cumulative decrease in mean abundance (95% CI: from 72.0% to 79.0%). These results support continued management concern about the population status of the *Brachyramphus* genus. Determining whether trends have differed between the two *Brachyramphus* murrelet species is an area of ongoing analysis.

Speakers: Gulf of Alaska
Marine Mammals

Baleen whales and tubenose seabirds—A chemosensory comparison?

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How filter-feeding baleen whales locate their prey remains a biological mystery. It is widely believed that whales cannot smell; however indigenous knowledge, anatomical and genetic data points to the contrary. Bowhead whales recently have been shown to have a complete olfactory bulb and humpbacks, at a minimum, have a rudimentary olfactory system. Baleen whales face a foraging "problem" that is similar to tubenose seabirds (e.g., petrels, shearwaters): how to find food in a patchy environment. Parallels exist between these taxa. Classic seabird studies revealed that tubenoses use olfactory-mediated foraging, in which they oriented into the wind upon approaching experimental "plumes" of food scent. More recent work has discovered avian attraction to dimethyl sulfide (DMS), a reliable indicator of zooplankton prey. We observed humpback whales (*Megaptera novaeangliae*) in southeastern Alaska for evidence of behaviors consistent with the use of odor cues. Our data suggest that whales orient into the wind ($n = 231$, $df = 1$, $X^2=54.6$, $P <0.0001$). This suggests that humpbacks are well positioned to perceive volatile chemical stimuli. We hypothesize that whales, like seabirds, use olfaction to detect DMS to locate dense swarms of patchy zooplankton prey. Other patterns support this notion. Within whales, baleen species that specialize on zooplankton (Suborder Mysticeti) have more notable olfactory systems than toothed whales (Odonticeti). A similar diet-based dichotomy occurs in seabirds between tubenoses (Order Procellariiformes) and Charadriiformes. Drawing upon general principles of avian chemosensory behavior may help us gain new insight into the feeding biology of whales. Analysis of data collected in September 2012 from krill-feeding humpback whales tagged with multi-sensors to determine direction of travel and document fine-scale foraging behavior will provide further insight. The approach promises to yield information about an entirely overlooked mode of perception in whale biology applicable to other key behaviors, such as migration and social interactions.

Using acoustic assessment of pelagic backscatter to assess prey use and niche separation of fin and humpback whales near Kodiak Island, Alaska

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Fin and humpback whales are top-level predators and depend on seasonally intensive feeding to meet high energetic demands. As a result, consumption by these whales is substantial and directed at a variety of zooplankton and forage fish in diverse habitats. In the waters surrounding the Kodiak Archipelago, fin and humpback whales can be found year-round and frequently overlap spatially and temporally. The Gulf Apex Predator Prey study (GAP) investigated the prey use and potential for niche separation between these two sympatric species by combining concurrent analysis of horizontal and vertical whale distribution, through attachment of real-time suction cup tags, with acoustic assessment of pelagic backscatter. Pelagic backscatter was classified as either “fish” or “zooplankton” using multi-frequency differencing techniques. Results suggest that fin whales likely rely more heavily on zooplankton, while humpback whales favor fish. Humpback whales were also shown to have a preference for capelin over juvenile pollock and zooplankton when all were available. However, the diets of these whales may overlap when zooplankton, primarily euphausiids, densities are very high.

Speakers: Gulf of Alaska
Marine Mammals

Colonization in action: Understanding the impacts of sea otters on soft-sediment invertebrate communities

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The influence of sea otters (*Enhydra lutris*) on nearshore marine communities has been widely studied in kelp-forest ecosystems; however less is known about their impacts on unconsolidated substrate prey communities. In Southeast Alaska, the recolonization by sea otters into areas where they have been long absent (~100 years), provides a natural experiment with which to examine the response of soft-substrate prey communities to the return of a top predator. In 1995 sea otters began to colonize Glacier Bay National Park and Preserve, Alaska, expanding their range in the region with growth rates exceeding the predicted maximum. Utilizing the uneven pattern of sea otter colonization over space and time to quantify the direct and indirect effects of sea otter predation, we report on a long-term (12+ years) comparative study of sea otter foraging ecology and invertebrate prey communities. We monitored 43 intertidal sites and 12 subtidal sites throughout Glacier Bay, before and after colonization at sites occupied and not-occupied by sea otters, measuring the size and abundance of all urchins, clams, and horse mussels greater than 14 mm. Using GIS and aerial surveys we estimate the cumulative magnitude of the sea otter effect at each sampling site as determined by density and occupancy time. We examine the effects of predation on the abundance, size frequency, biomass, and diversity of epibenthic and infaunal invertebrates on a continuous scale, comparing sites across a gradient of sea otter effect and sites not yet used by otters. Concurrently, we conducted observations of sea otter foraging to measure temporal variation in diet composition and energy recovery. We used these metrics to estimate the direct effects of predation on invertebrate species. Consistent with findings in rocky reefs, we found significant changes in both the size distribution and abundance of prey species consumed by sea otters. Continued occupation and recolonization by sea otters into these systems will likely have indirect effects that cascade throughout intertidal and subtidal communities influencing available prey biomass and causing changes in community structure for sea otters and other nearshore residents.

Overlooked and underappreciated: The role of squids in the diet of Steller sea lions (*Eumetopias jubatus*) in southeast Alaska

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Although the diet of Steller sea lions has been widely studied in southeast Alaska for over two decades, the dietary role of cephalopods (squids in particular) has been largely ignored. We sought to understand the relative importance of an understudied prey type—cephalopods—in the diet of sea lions in southeast Alaska. Sea lion scats were collected opportunistically between 2000-2010 from rookeries and haulouts and the prey groups were identified using hard part analysis. Squid beaks were examined to determine which species were consumed. The importance of squids and octopuses in the diet of sea lions in southeastern Alaska was evaluated by examining the frequency of occurrence of the primary prey types. In our analysis, the frequency of occurrence indicated the proportion of the sampled scats, which contained squids or octopuses. Overall, we found that the frequency of squid occurrence was higher near resting sites (haulouts: ~11%, n=1313 scats) than breeding sites (rookeries: ~2%, n=2308). However, the frequency of octopod occurrence was the same (1%) in both areas. We then estimated the seasonal frequency of cephalopod occurrence at haulouts (all seasons) and rookeries (only summer) that were sampled in at least 4 years. We found that ~19% of the scats sampled on haulouts in the fall (n=401) contained either squids or octopods, followed by ~18% in winter (n=500), ~12% in spring (n=848) and only ~10% in summer (n=2858). Cephalopods represented a much smaller proportion of sea lion diet on the rookeries, as only ~5% of the sampled scats (n=2079) contained squids or octopuses. Preliminary examination of beaks in scat samples indicated 9 squid species: *Berryteuthis magister*, *Gonatus berryi*, *Gonatus middendorffi*, *Gonatus onyx*, *Gonatus pyros*, *Histioteuthis sp.*, *Onychoteuthis borealijaponica*, *Rossia pacifica*, and *Taonius borealis*. Some of these species are high in energetic value. These findings suggest that many squid species are consumed and that overall squids comprise a larger and more nutritionally important part of Steller sea lion diet in southeast Alaska compared to octopus. Furthermore, squids are most important for sea lions occupying haulout sites during the fall and are a seasonally important prey item.

Speakers: Gulf of Alaska
Marine Mammals

Augmenting Steller sea lion surveys in the Western Aleutians with unmanned aircraft

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Since the 1970s, the population of Steller sea lion (SSL) has declined dramatically and the western stock is currently listed as an endangered species. This project is developing and demonstrating novel methods for imaging SSL sites with the accuracy and fidelity necessary for population surveys and at a cost low enough to allow frequent monitoring. The National Marine Mammal Laboratory (NMML) conducts manned aerial surveys of SSL throughout their Alaska range. Manned flights must adhere to stringent requirements for wind, visibility, and minimum flight elevation for both safety (human) and noise (SSL) concerns. These limitations inhibit NMML's ability to consistently and adequately survey remote locations. Consequently, individual sites or entire segments of the survey often cannot be completed on an annual basis. Due to a recent biological opinion involving the Steller sea lion some of the most profitable fisheries in North America have been closed or drastically curtailed. Obtaining quality data on the animals is paramount to both evaluating the animal's recovery plan and the fisherman's viability. Ship-based unmanned aircraft (UAS) could provide a cost-effective, safe means of surveying SSL in remote locations. UAS have a significantly lower noise signature and consequently can fly at lower altitudes without disturbing the SSL on their terrestrial sites, which enables operations to proceed under low ceiling weather conditions that often prevent manned survey flights. Additionally, the UAS can operate for extended periods, which may help locate previously unknown SSL haulouts or rookery sites. The lack of airfields does not limit the operations. This presentation describes the project's experiences with flying multiple small UAS from a surface vessel in the Western Aleutians and discusses the data processing methods that are under evaluation. The process that the University undertook to select the most appropriate aircraft for the mission highlights the pros and cons of the available small UAS inventory for such a mission. The environmental conditions found in the Western Aleutian Islands have resulted in some novel unmanned aircraft experiences that should be considered for future product development.

Posters: Arctic

Arctic - Ecosystem Perspectives

An Overview of Selected Biological and Biogeochemical Processes on Hanna Shoal, Northern Chukchi Sea, Alaska

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The Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) project expanded field efforts in 2012 and focused on the shallow Hanna Shoal region of the northern Chukchi Sea, as well as the Distributed Biological Observatory transect across Barrow Canyon. The shallow, but complex bathymetry of Hanna Shoal appears to influence the productivity of the water column and organic sedimentation processes. Based upon field efforts in 2012, as well as prior work, inshore waters are less nutrient rich and water column chlorophyll (up to 1000 mg chlorophyll a per square meter over the whole water column) also increases offshore to the north and west. However, benthic biomass, sediment oxygen demand and chlorophyll deposited to the surface sediments (up to 20 mg per square meter) do not always mimic these water column processes. These organic sedimentation indicators tend to be higher to the south, including in waters to the south and east of Hanna Shoal where large populations of walruses have also been observed to forage on the benthos in the summer from remnant sea ice. The emerging picture suggests that the complex current system rotates richer organic materials around the periphery of Hanna Shoal in a clockwise direction, leading to a shoreward enhancement of organic material deposition. These pelagic – benthic coupling characteristics will be considered in the context of the larger Chukchi marine ecosystem.

The Offshore Northeastern Chukchi Sea: A Complex High-Latitude Ecosystem

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In 2008–2010, we conducted an interdisciplinary ecological study (Chukchi Sea Environmental Studies Program; funded by ConocoPhillips, Shell, and Statoil) in and near three proposed exploratory oil and gas prospects in the offshore northeastern Chukchi Sea during the open-water season. Some aspects of this ecosystem function as a classical pelagic–benthic dichotomy, whereas others suggest unusual ecosystem-level attributes. The Klondike study area functions as a pelagic system, whereas the Burger study area is primarily a benthic system; the Statoil study area has both pelagic and benthic attributes. Klondike has lower benthic abundance and biomass and more oceanic zooplankton, fishes, zooplankton-feeding seabirds, and pelagic-feeding seals than does Burger, which has benthic communities with high abundance and biomass, primarily neritic zooplankton, and more benthic-feeding marine mammals than Klondike; Statoil has characteristics of both ecosystems. Various water masses impinge onto all study areas seasonally and interannually, and patterns of sea-ice retreat vary interannually. These variations alter some of this pelagic–benthic dichotomy, and some aspects of this ecosystem suggest unusual structure.

The Arctic Research Consortium of the United States (ARCUS)

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The Arctic Research Consortium of the United States (ARCUS) is a nonprofit membership organization composed of universities and institutions that have a substantial commitment to research in the Arctic. ARCUS was formed in 1988 to serve as a forum for planning, facilitating, coordinating, and implementing interdisciplinary studies of the Arctic; to act as a synthesizer and disseminator of scientific information on arctic research; and to educate scientists and the general public about the needs and opportunities for research in the Arctic. ARCUS, in collaboration with the broader science community, relevant agencies and organizations, and other stakeholders, coordinates science planning and educational activities across disciplinary and organizational boundaries. Examples of ARCUS projects include: Arctic Sea Ice Outlook – an international effort that provides monthly summer reports synthesizing community estimates of the expected sea ice minimum. Sea Ice for Walrus Outlook – a resource for Alaska Native subsistence hunters, coastal communities, and others that provide weekly reports with information on sea ice conditions relevant to walrus in Alaska waters. PolarTREC (Teachers and Researchers Exploring and Collaborating) – a program whereby K–12 educators and researchers work together in hands-on field experiences in the Arctic and Antarctic to advance polar science education. ArcticInfo mailing list, Witness the Arctic newsletter, and the Arctic Calendar – communication tools for the arctic science community to keep apprised of relevant news, meetings, and announcements. Coordination for the Study of Environmental Arctic Change (SEARCH) program – aims to provide scientific understanding of arctic environmental change to help society understand and respond to a rapidly changing Arctic. More information about these and other ARCUS activities can be found at the ARCUS website at: http://www.arcus.org.

The Pacific Marine Arctic Regional Synthesis (PacMARS)

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The Pacific Marine Arctic Regional Synthesis (PacMARS) is an effort to assemble by mid-year 2013 up-to-date documentation that contributes to understanding the Pacific-influenced arctic ecosystem that extends from Saint Lawrence Island through Bering Strait into the Chukchi and Beaufort Seas. Our objective is to compile the best available knowledge from local communities, peer-reviewed social and natural sciences, as well as less readily available sources. As seasonal sea ice declines in the Arctic, and reached record minima in 2012, oil and gas exploration is increasing as is ship traffic using Bering Strait. Within this context of environmental and likely socio-economic changes, wildlife populations and human communities are adjusting to these shifts in seasonal sea ice coverage and climatic warming that has been much more obvious than at lower latitudes. Subsistence hunting patterns in the Arctic are changing, and it is also clear that many organisms, from plankton to top predators may be changing their migration and foraging patterns; productivity within the foodweb may also be changing. The PacMARS effort is structured to address the uncertainties in knowledge as well as to summarize what is already known. We are seeking input from the scientific community, local residents, and other stakeholders in assembling the best current knowledge in a short time frame. The mechanisms for input will include public and invited meetings that will concern data sources, and outreach at scientific conferences, including an Open Science Workshop in collaboration with the Synthesis of Arctic Research (SOAR) program on January 20, 2013, just prior to the Alaska Marine Science Symposium. Community based meetings in Nome, Kotzebue and Barrow will also be held in early 2013 that will seek the participation and knowledge of the traditional Iñupiat and Saint Lawrence Island Yupik communities. Follow-up review of written synthesis products will provide additional methods to gather together the best information on vulnerabilities, potential mitigation, and opportunities in the Arctic during a period of rapid environmental change.

Characterization of the inter-annual ambient noise baseline off Icy Cape, Alaska and its primary sources (2010-2012)

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Long-term passive acoustic data collection efforts allow for the opportunity to broadly characterize the inter-annual periodicity of physical processes, vocally active behaviors of biological sources and the contribution of anthropogenic activities to the overall local ambient noise environment. Such a baseline description is even more essential in remote and hostile locations like the Chukchi Sea, where industrial development (energy exploration, shipping) is accelerating and other monitoring methods become limited by cost or harsh conditions. As part of NOAA's CHAOZ (CHukchi Acoustic, Oceanographic and Zooplankton) project, a Marine Autonomous Recoding Unit was deployed 65 miles northwest off Icy Cape over two consecutive years, collecting 50% duty-cycled (2010-2011) and continuous (2011-2012) acoustic data at a sampling frequency of 2 kHz. Using a custom quantitative analysis approach developed in Matlab, ambient noise metrics such as sound equivalent level Leq, spectrograms (in both linear and 1/3rd octave frequency band format) and power spectral density (PSD) were computed at various integration timescales (30 s, 30 min, 2 hr) to visualize noise sources occurring in different timescales. Visual inspection of the spectrograms detected daily presence/absence of seismic surveys to divide the year-long acoustic records into two periods: with and without the impulsive anthropogenic disturbance. Seismic surveys largely coincide with ice-free months: early August through mid October. PSDs were represented as statistical distributions (5th, 50th and 95th percentiles) and cumulative percent distributions illustrate the percentage of time reached by particular levels during the two different periods across both years. Sound levels were correlated with local wind speed data (in 6 hr, 0.25°x0.25° resolution, measured by satellite scatterometry) in order to estimate the contribution of noise from surface breaking alone. CHAOZ is a collaboration between NOAA Alaska Fisheries Science Center (AFSC) and the Pacific Marine Environmental Laboratory (PMEL) with support from the Bureau of Ocean Energy Management (BOEM).

Synthesis of Arctic Research (SOAR) – Physics to marine mammals in the Pacific Arctic

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The Synthesis of Arctic Research (SOAR) brings together a multidisciplinary group of Arctic scientists and Alaskan coastal community representatives to explore and integrate information from completed and ongoing marine research in the Pacific Arctic (www.arctic.noaa.gov/soar). The goal of SOAR is to increase scientific understanding of the relationships among oceanographic conditions (physics, chemistry, sea ice), benthic organisms, lower trophic pelagic species (forage fish and zooplankton), and higher trophic species (i.e., seabirds, walrus, whales) in the Pacific Arctic, with particular emphasis on the Chukchi Sea oil and gas lease sale areas. The synthesis is supported via a MOU between the BOEM-Alaska Region and the NOAA-PMEL, and is guided by a 13-member Science Steering Committee formed of senior scientists and local residents with decades-long experience in ecosystem-based resource management. In March 2012, over 50 scientists and Arctic residents attended a Science Workshop in Anchorage, Alaska, to develop science themes and research questions for the first phase of the SOAR program. Three themes identified for synthesis were: (1) Hotspot mechanisms and trophic dynamics; (2) Year in the life of selected seabirds and marine mammals; and (3) Responses to step-change in physical drivers of the marine ecosystem. Workshop participants proposed 20 projects for synthesis within the three themes, as described in the workshop report available on the website. Funding to fourteen synthesis projects began in August 2012, with analytical work resulting in draft manuscripts suitable for submission to a peer-reviewed journal anticipated by December 2013. The goal is to publish all papers as a special issue or as a stand-alone theme section of an appropriate science journal. The SOAR program will be completed in 2016, providing vital information to marine resource managers and guidance for future research activities.

Status of ShoreZone Mapping in Alaska and in the Pacific Northwest

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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 dataset includes imagery with mapped geomorphic and biological attributes in a searchable geospatial dataset. 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. There are many applications for this data including: oil spill contingency planning, habitat research, and coastal resource evaluations. Approximately 104,200 km of ShoreZone imagery exists for the Pacific Northwest coastline including the entire shoreline of Oregon (1,795 km), Washington (4,933 km), British Columbia (37,619 km), and 59,853 km of the Alaskan coastline (~79%). The Alaska ShoreZone imaging and mapping project is on-going with 75% of the coastal imagery mapped or with mapping in progress and 21% (15,597 km) of the coastline remaining to be imaged. The Alaska imagery can be viewed online at http://alaskafisheries.noaa.gov/shorezone/. The Alaska ShoreZone program is built on a foundation of multiple funding and contributing partners, including state and federal governmental agencies, nonprofit organizations, and private industry, as well as resource managers, scientists, and spatial data specialists. The multi-organization program provides a framework to build on and supports a contiguous, integrated coastal resource database that extends from Southeast Alaska through the Gulf of Alaska, the Alaska Peninsula, Bristol Bay, and northwards to Kotzebue Sound, and the Chukchi and Beaufort Seas. The program goal is to have all of the Alaskan shoreline imaged and mapped using the ShoreZone protocol and to make this data web accessible. The partnership is actively seeking additional partners to help accomplish this goal.

Trophic relationships and carbon flow of the northeastern Chukchi shelf: extending isoscapes to the highly productive Hanna Shoal

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The Hanna Shoal Ecosystem Study, an extension of the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA), includes a component to construct trophic relationships and carbon flow through the food web of the shoal and nearby areas of the Chukchi Sea. We use a multi-disciplinary approach to provide a baseline characterization of the Chukchi Sea benthic ecosystem to provide a benchmark against which future changes, related either to climate or from oil and gas activities, could be measured. This component of the study relied on plankton tows, benthic grabs, and beam trawls to collect plankton, invertebrate, and fish samples in August 2012 from the USCG Icebreaker Healy. Based on the abundance and biomass measurements of the invertebrate assemblages and the C and N stable isotope signatures at all trophic levels, we describe the distributions and trophic relationships of the benthic infauna and epifauna of the Hanna Shoal food web. High infaunal and epifaunal invertebrate biomass reflects the strong influence of advected and in situ pelagic production on the benthos. Yet the Hanna Shoal ecosystem displays substantial spatial heterogeneity as reflected by the variations in sediment, hydrographic, and ice conditions across the study area. Infauna was dominated by polychaetes and bivalves, although amphipods dominated at some stations. The brittle star, *Ophiura sarsii*, was ubiquitous across the entire study area, while the dominance of other epifaunal species varied. We examine the variations in the spatial distributions of fauna with respect to changes in trophic structure and the physical characteristics of this highly productive and diverse ecosystem.

The Distribution, Abundance, and Diversity of Benthic Infauna in the Northeastern Chukchi Sea in Relation to Marine Mammal Occurrence

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During summers 2009 and 2010, the northeastern Chukchi Sea was quantitatively sampled for benthic infauna under the Chukchi Sea Offshore Monitoring in Drilling Area - Chemical and Benthos (COMIDA-CAB) program funded by the Bureau of Ocean Energy Management (BOEM). Our investigation produced a benthic species inventory of 365 taxa obtained from 142 individual van Veen grab samples (0.01 m-2) collected at 53 stations. Infaunal abundance was dominated by the Annelida (38%), Mollusca (22%), and Arthropoda (21%). Comparably large concentrations of bivalves (up to 1750 n m-2), amphipods (up to 1820 n m-2), and polychaetes (up to 4665 n m-2) were documented from multiple stations west of and within Barrow Canyon. Concentrations of bivalves were also collected southwest of Hanna Shoal. Gray whale and walrus aerial counts collected by the National Marine Mammal Laboratory (NMML) from 2008-2010 were clearly correlated with benthic amphipod and bivalve abundance, which represent the major dietary components of gray whales and walrus, respectively. COMIDA-CAB infaunal abundance and biomass distributions, when mapped against historical data from Stoker (1978) and Feder et al. (1989), showed visually comparable results and spatial trends among all three studies. An analysis between physical factors and biota distribution using a biota and environment matching routine in the software PRIMER revealed that water depth, bottom water salinity, and sediment C:N ratios exhibited the greatest influence on infaunal distribution.

The Pacific Marine Arctic Regional Synthesis (PacMARS) Data Management and Visualization Strategy

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The Pacific Marine Arctic Regional Synthesis (PacMARS) effort will facilitate new synergies in understanding of the marine ecosystem in the greater Bering Strait region, including the northern Bering, Chukchi and Beaufort seas. The PacMARS project is undertaken within the context of recent and ongoing synthesis efforts, indicating strong recognition and scientific consensus that the Bering Strait region is an ecosystem at a pivotal point in the context of environmental change. One goal of the data synthesis is to document where relevant data resides. To manage the data for this synthesis effort, the Earth Observing Laboratory (EOL) of the National Center for Atmospheric Research (NCAR) is bringing together metadata from an international selection of existing data sets, and archiving new data in the PacMARS Data Archive (pacmars.eol.ucar.edu). EOL has implemented a Geographical Information System (GIS) MapServer to enable the PacMARS team to visualize and access available marine ecosystem data, products and other value added content. The Mapserver is a tool that allows the researcher to integrate and visualize various "layers" of data. Data types such as chlorophyll, primary production, hydrography, currents, and winds can be mapped into multiple GIS layers. Selecting overlays to view in the Mapserver groups datasets and shows interrelationships, while also displaying base layer information, such as bathymetry, multibeam data, and gridded lat-long. Each dataset site on the map can be expanded to display ancillary information, as well as a link to directly access the data. This synthesis effort will contribute to an understanding of north Pacific ecosystems in order to enable effective management and sustainable use of marine resources, from subsistence use to fisheries to industrial exploration and development. Special focus will be given to informing local communities about PacMARS research in the region. The resulting EOL data inventory/archive for PacMARS will allow analysis of recent and historical data for the Chukchi/Beaufort region to permit improved understanding of processes contributing to the changes ongoing in the region. The objective of this poster is to summarize and highlight data management activities (both planned and completed) to accomplish project requirements.

Spatial and Temporal Patterns for Trace Metals in the Sediment, Seawater and Biota of Hanna Shoal and Adjacent Areas of the Northeastern Chukchi Sea

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The geographic center of the COMIDA (Chukchi Sea Offshore Monitoring in Drilling Area) Project was extended northward to the area of Hanna Shoal during 2012 with continued funding from the Bureau of Ocean Energy Management. The expanded project is designed to identify and study important physical, chemical and biological processes that contribute to the high concentration of marine life in the area of Hanna Shoal. Trace metals are being used in the study to identify natural biogeochemical processes and to serve as indicators of any impacts from human activities, including exploration for oil and gas. Bottom sediments on Hanna Shoal are coarser grained than in surrounding, deeper locations. Concentrations of metals are naturally lower in these coarse-grained sediments. For example, concentrations of Al and total Hg in Hanna Shoal sediments are ~1% and 5 ng/g, respectively, relative to 6-7% Al and 30-40 ng/g Hg at off-shoal stations. Metal concentrations in bottom sediments on and off the shoal are presently at background with predictable ratios to Al, except for selected instances of As and Se enrichment in surface sediments due to natural diagenetic processes. Concentrations of dissolved nutrients and nutrient-type metals such as Cd are typically lower (30-40 ng/L for Cd) in the shallower water of Hanna Shoal (<30 m) relative to dissolved Cd concentrations of 30-76 ng/L in deeper water (40-50 m) at off-shoal locations where active nutrient and metal regeneration are occurring. Metal concentrations also have been determined for plankton and a variety of benthic organisms. Among our observations to date, we found that concentrations of methyl Hg in the northern Neptune whelk (*Neptunea heros*) and snow crab (*Chionocetus opilio*) vary inversely with benthic biomass, possibly due to a finite supply of Hg.

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

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SEARCH, an interdisciplinary interagency program, works with academic and government agency scientists to plan, conduct, and synthesize studies of arctic change. The SEARCH vision is to provide scientific understanding of arctic environmental change to help society understand and respond to a rapidly changing Arctic. Toward this end, SEARCH: (1) Generates and synthesizes research findings and promotes arctic science and scientific discovery across disciplines and among agencies; (2) Identifies emerging issues in arctic environmental change; (3) Provides information resources to arctic stakeholders, policy-makers, and the public to help them respond to arctic environmental change; (4) Coordinates with national arctic science programs integral to SEARCH goals; (5) Facilitates research activities across local-to-global scales, incorporating stakeholder concerns; (6) Represents the U.S. arctic environmental change science community in international and global change research initiatives. Current SEARCH activities include: (1) Arctic Observing Network (AON) planning and recommendations; (2) Arctic Sea Ice Outlook; and the (3) Sea Ice for Walrus Outlook. SEARCH is also currently undertaking a strategic planning process to define research priorities for the next 3-5 years. For further information, see: http://www.arcus.org/search.

Arctic - Humans

Integrated Arctic Management - Report to the President

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In December 2012, the US Government Inter-agency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska presented a report to the President outlining an Integrated Arctic Management approach to resource management decisions in the Arctic. The report addressed: 1. The identification of ecologically and culturally important areas, biota, and processes, natural resources, and key drivers of environmental changes in the Arctic across agency jurisdictions and boundaries, 2. The identification of anthropogenic, environmental, and climatological trends that could affect these resources over time, and 3. The identification of commercial, societal, and governmental needs and trends that cut across agency jurisdictions, boundaries, and sectors such as energy, transportation, shipping, and tourism that could lead to future infrastructure-related needs in the Arctic. This poster provides an overview of the report, its recommendations, and pending implementation.

Impact Monitoring for Offshore Subsistence Hunting

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The purpose of this project is to initiate monitoring efforts of offshore subsistence hunting for key marine mammals among the two communities, Point Lay and Wainwright, that are most proximate to recent Outer Continental Shelf (OCS) oil and gas leases and to currently anticipated offshore exploration and development in the Chukchi Sea. The Bureau of Ocean Energy Management (BOEM) seeks to establish an updated baseline in the area and to monitor on an annual basis any significant changes in offshore subsistence harvest activities over time. To meet this goal, Stephen R. Braund & Associates (SRB&A) has implemented a program to monitor offshore subsistence hunting in Point Lay and Wainwright beginning in 2009. Collecting data on hunting and harvesting activities will allow for the assessment and monitoring of potential effects related to development and the identification of mitigation strategies to help lessen those effects. This project involves working with local marine mammal hunters to document where offshore subsistence activities occur with the use of Global Positioning System (GPS) units, followed by interviews with hunters to gather additional data about their offshore hunting trips. The study gathers data on offshore hunting activities, including the number and composition of hunting groups, duration of hunting activities, the locations of search areas and harvest strikes, number of prey harvested, harvest costs, and hunter observations regarding weather and ice conditions, access problems, increased hunting risks or costs, and resource changes. Community approval and identification of study participants began in August of 2009. The 2010 field season began in March 2010 in the communities of Point Lay and Wainwright. Three years (2010, 2011, and 2012) of data collection, data entry, and analysis are nearing completion. This presentation focuses on the methods and preliminary results of this offshore monitoring study.

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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, conducted by Stephen R. Braund & Associates under contract to the U.S. Department of the Interior, Bureau of Ocean Energy Management, will evaluate the effectiveness of industry's pre-lease mitigation strategies and post-lease operations. This presentation summarizes the efforts to inventory concerns and mitigation proposals and decisions associated with the six projects and results of the fieldwork and 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 inventory was to guide the development of interviews with industry and government informants. Inventory results identified over 800 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. Following the inventory of mitigation decisions, the study team identified a subset of mitigation measures directly related to subsistence activities to carry forward in the interviews and analysis. Key informants for the interviews include representatives from agencies, industry, and the community of Nuiqsut. The presentation focuses on a description of the mitigation process from the perspective of key informants in industry, agencies, and Nuiqsut community residents and an analysis of the effectiveness of selected mitigation measures directly related to Nuiqsut subsistence.

Connecting youth and elders through a Sense of Place: a North Slope perspective

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Physical and cultural landscapes are changing on the North Slope of Alaska. Coastal traditional knowledge is important for future generations and coastal management. 'Sense of Place: Inupiat Coastal Knowledge', aims to connect youth and elders using film and aerial imagery collected during the ShoreZone coastal mapping program. The 2012 BOEM North Slope ShoreZone program involved helicopter support, and the 'Sense of Place' project used the helicopter and imagery to engage communities about their coast. The goals were to help connect youth and elders, preserve traditional coastal knowledge, and provide an education opportunity for youth in Kaktovik and Point Lay. Youth learned how to make a movie through a film workshop and interviewed elders about their coastal knowledge, stories, and observations of change. Some students experienced filming from the ShoreZone helicopter around their village. The film workshop week culminated into a film screening in the community with a total of five movies created by eight students in both villages. 50-60 people in each village attended the film screenings. Discussions are underway for similar projects in other coastal villages of the North Slope, Kotzebue Sound, and the Canadian Arctic. Project support is provided by the Arctic Slope Community Foundation, ExxonMobil, the North Slope Borough, and ConocoPhillips Alaska.

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2012 Accomplishments in Implementing the NOAA Arctic Vision & Strategy

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In February 2011, the National Oceanic & Atmospheric Administration published its priorities for Arctic activities. This document, called the Arctic Vision and Strategy formed the basis of its internal agency planning and commitments to inter-agency processes such as the National Ocean Policy Implementation Plan. The Vision and Strategy focuses on six areas: 1) Forecast Sea Ice 2) Strengthen Foundational Science to Understand and Detect Arctic Climate and Ecosystem Changes 3) Improve Weather and Water Forecasts and Warnings 4) Enhance International and National Partnerships 5) Improve Stewardship and Management of Ocean and Coastal Resources in the Arctic 6) Advance Resilient and Healthy Arctic Communities and Economies. This poster will highlight the projects and partnerships the agency has accomplished to date and its plans for the upcoming field season.

Update on NOAA-Shell/ConocoPhillips/Statoil Data Sharing Agreement

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In August 2011 NOAA, Shell, ConocoPhillips, and Statoil signed a Memorandum of Agreement to provide a framework for collaboration communication, and information-sharing. The Agreement is intended to inform effective societal, economic, and environmental decision-making regarding Arctic resources utilization through a better understanding of the physical processes governing sea ice, the atmosphere, and the ecological character of the Arctic. This poster will provide an update on the implementation of the Agreement and next steps.

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Working Group on Coordination of Domestic Energy Development and Permitting in Alaska

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The Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska was established by Executive Order 13580, signed by the President on July 12, 2011, and works to coordinate the efforts of Federal agencies responsible for overseeing the safe and responsible development of onshore and offshore energy in Alaska. The goal of the group is to improve the efficiency of the Federal government, ensuring that resource development projects in Alaska comply with health, safety, and environmental protection standards while achieving the goal of reducing our dependence on foreign oil. This poster will give an overview of the working group and its activities.

Alaska Region Bathymetric Digital Elevation Model

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We provide an overview our efforts to improve existing bathymetric digital elevation models (DEMs) that span the greater Alaska region by salvaging data from historical Russian nautical charts and by processing newly available shiptrack soundings from the Bering, Chukchi and Beaufort Seas. Oceanic DEMs allow scientists, natural resource managers, students, and others to graphically depict their domain of interest, often in conjunction with other geospatially-referenced data. While existing DEMs suffice for some visualization needs, many applications require the best possible representation of bathymetric depths. For example, DEM quality and resolution is intimately tied to the quality of numerical model results, which in turn inform oil spill responses, search and rescue missions, ecosystem models, and countless other scientific research projects. To improve DEM quality, we assembled one of the most comprehensive sets of unclassified bathym etric soundings between the Russian Far East and western Canada and then created the publicly available Alaska Region Digital Elevation Model (ARBDEM), gridded at ~1 km horizontal resolution and spanning 130°E to 120°W and 45°N to 75°N. We present the current state of the ARDEM grid and provide a preview of upcoming improvements. We welcome data contributions that could help further improve the ARDEM grid.

Alaska Monitoring and Assessment Program – Chukchi Sea 2010 and 2011 Survey: Relative Concentration Patterns Between Polycyclic Aromatic Hydrocarbons in Sediments and Epifauna

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In 2010 and 2011 the Alaska Monitoring and Assessment Program (AKMAP) conducted a multidisciplinary assessment in the Chukchi Sea covering a region from Pt Hope to Barrow. The surveyed region lies within a 25 to 50 mile exclusion corridor between the near shore (~10 meter depth) and the Federal Lease Sale 193. Objectives of this initial survey were to 1) establish the current environmental status over this geographic region using a probabilistic survey design, and 2) seek associations between selected indicators and condition of the ecological resource. PAHs were of a specific environmental concern because of their toxicity to marine organisms and the potential release to the environment from oil development activities. This poster describes PAH sediment levels in relation to established sediment quality guidelines, bioavailability of sediment PAHs, and the utility of using different epifauna as bioindicators of PAH exposure.

Arctic - Climate and Oceanography

Sea Ice Forecasting - How NOAA Might Do It Better!

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Poster Arctic barrier island-lagoon systems provide essential habitats for migratory birds and diadromous fish. In contrast to many areas of Alaska where pelagic environments support the highest bird densities, the most important habitats in the Beaufort Sea for seabirds and shorebirds are the nearshore, lagoon, and littoral zones that are important areas for staging, brooding, and molting. The warm, detritus-laden coastal waters provide rich summer feeding areas for fish that migrate annually from freshwater overwintering areas. These shallow lagoon ecosystems and coastal habitats depend upon freshwater and sediment influx from glacial and non-glacial rivers, as well as intermittent exposure to saline ocean water modulated by the presence of barrier islands. These barrier islands are key features in the coastal Arctic landscape, as they regulate the exchange of ocean and lagoon waters and provide protection of low-elevation mainland coastline habitats against high-energy waves, run-up, and storm surge. In this study, supported by the Arctic Landscape Conservation Cooperative and U.S. Geological Survey, a processed-based numerical modeling system was used to understand the migration and partial deterioration of a barrier island in eastern Arctic Alaska. The model was used to simulate shoreline change over a 20 year time-period from 1980 to 2000 and results were compared to shoreline positions obtained via analysis of aerial imagery. The model was then applied under conditions of projected storm events to estimate morphologic change to and inundation of the barrier island during the 21st century up to the year 2100. Preliminary results indicate deterioration of the barrier island compared to its present-day condition, greater exchange of the open ocean saline water with brackish lagoon water, and exposure of the lagoon hinterland to wave action and inundation by storm surge. Although this study focused on a small barrier island-lagoon system in eastern Arctic Alaska and thus may not represent future conditions for the entire Alaska Arctic coastline, the study illustrates the fact that some habitats are likely to undergo significant change and outlines an approach for assessing the impact to coastal habitats in response to a changing Arctic climate.

Circulation, hydrography and ice retreat around Hanna Shoal in Summer 2012

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Numerical models of the Chukchi Sea predict a topographically-steered, clockwise circulation around Hanna Shoal, which eventually feeds Barrow Canyon and enters the Arctic Ocean. In summer, this circulation should carry warm Bering Shelf Water along the west and north side of the Shoal, which gradually displaces cold shelf waters masses and provides heat to melt ice. Although the model predictions have been long-standing, there have been no observations available for comparison. In August 2012, the USCGC Healy occupied several CTD and vessel-mounted ADCP transects that radiated outward from Hanna Shoal. Over the enter region, the bottom waters consisted of winter water, but the densest water (T< -1.7oC and S~33.4) was trapped to the northwestern and northern flanks of the Shoal. Dense bottom waters were separated from surface meltwaters (T~-1oC and S<30) by a strong halocline at ~ 20 m depth. The sole exception to this observation was a ~10 m thin layer of moderately warm and salty Bering Shelf Water observed along the northwestern side of the Shoal between the halocline and surface. ADCP velocities indicate a clockwise circulation around the northern side of the Shoal with speeds of from 15 – 30 cm s-1. East of the Shoal the flow was southwestward and confined to the Shoal's flank. Farther to the east the flow was more variable and tended southeastward. The data thus corroborate the clockwise circulation predicted by models. Our results are corroborated by the maps depicting ice retreat through August and September. Heavy ice concentrations (>70%) occurred over the Shoal through most of August, but retreat commenced on the northwest side of the Shoal in the form of a narrow tongue, likely associated with the arrival of the Bering Shelf Water captured in the hydrography. Retreat then progressed around the north side of the Shoal before ice retreated over the Shoal itself. To some extent the slow retreat of ice from the top of the Shoal was associated with grounded ice, the results are also consistent with the notion that a Taylor column forms over Hanna Shoal.

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Configuration of High Frequency Radar observations in the Southern Chukchi Sea

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In recent years, monitoring offshore surface circulation in the Arctic Ocean with high-frequency radar has become an issue of increasing practical importance. In this study, radar positions are optimized by minimizing the reconstruction errors of the surface currents in the southeastern portion of the Chukchi Sea. By means of an adjoint sensitivity technique, it is shown that in the case of two available radars, their optimal (i.e. most favorable) location is at Kivalina, a settlement near the strongest outflow of the Alaskan Coastal Current from the monitored domain. The least favorable location of the pair is at Shishmaref, a settlement near relatively weak inflow into the region as observed from the coast. The results are verified using observational system simulation experiments (OSSEs) performed in the framework of 4D variational assimilation of simulated radar observations into a numerical model. It is shown that correct specification of the first guess solution is of primary importance for getting realistic results for both sensitivity analysis and OSSEs. This emphasizes the necessity of obtaining accurate high-resolution climatologies for future ice-free offshore regions in the Arctic.

Oceanographic assessment of the planktonic communities in the northeastern Chukchi Sea during 2011

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Multidisciplinary studies in the Chukchi Lease area, sponsored by ConocoPhillips, Shell, and Statoil, have been establishing environmental baselines since 2008. In the 2011 field season, the study region was expanded in area more than 3 fold, now encompassing Hanna Shoal, and providing a better appreciation of the biological backdrop in the region. During 2011, chlorophyll and nutrients were low over the entire observation period. Both holozooplankton and meroplankton abundance and biomass were within the range of the previous three years, but there was a distinct increase in the relative proportion of larger-bodied animals. Gradients were also apparent in the abundance of many common species. A notable difference in 2011 from previous study years was the occurrence the copepod *Calanus hyperboreus* at a dozen stations over the Burger survey area, suggesting an incursion of Arctic Basin waters from the east, likely via Barrow Canyon. Zooplankton communities thus form a valuable means of establishing connectivity and transport of water masses in the region. Similar ecological studies in 2012 field season should continue to improve our appreciation of these connections.

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A Ten-Year Comparison of Organic Contaminant and Hydrocarbon Distributions in the Sediments and Biota of the Chukchi Sea: Initial Results from the Hanna Shoal Ecosystem Study

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The Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) program supported by the Bureau of Ocean Energy Management (BOEM) began in 2009 to establish a comprehensive baseline assessment of the Chukchi shelf and benthos prior to oil and gas exploration. In 2011, the Hanna Shoal Ecosystem Study extended these studies northward to a critical ecological area for environmental monitoring studies and ecosystem investigation. The Hanna Shoal region represents a highly productive region with unique physical interactions that drive both biological and chemical processes. The study to characterize biota, water column properties, and sediment chemical composition of the Hanna Shoal region began in the summer of 2012 using a randomized sampling grid across Hanna Shoal and ecologically important areas nearby. Surface sediments representing 17 sites spanning the study area have been analyzed for concentrations of both natural and anthropogenic contaminants (n-alkanes, PAHs) as well as lipid markers specific to ice-algae (highly branched isoprenoids, HBIs) to investigate distributional and temporal trends. Among the sites investigated, a subset of stations overlapped with sediments collected during the 2002 Shelf-Basin Interactions program, allowing a 10-year comparison of hydrocarbons in the Chukchi Sea. Additional analyses included mussels (*Musculus discors*) obtained near Barrow Canyon for analysis of organic contaminants. Surface sediments over the 10-year time span show largely similar results with low levels of polycyclic aromatic hydrocarbons (PAHs) present across the region and aliphatic n-alkane signatures distinctive of terrestrial organic sources. Organic contaminant concentrations were also low in bivalve tissues, with indications of ice-algal input to surface sediments in several areas of the Chukchi shelf.

CO_2 fluxes and their drivers in the rapidly changing western Arctic Ocean

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The Arctic Ocean is an important anthropogenic carbon sink due to the interplay of physical, biological and chemical forces that drive a net annual carbon flux from the atmosphere into the ocean. However, the strength and timing of these forces are rapidly changing in the face of climate change. Increased temperature, decreased sea ice cover and shifts in the timing and amount of primary productivity are expected to influence the capability of the ocean to take up CO_2. Due to the complexity of the system and uncertainty in the biological response, we studied the regional patterns of carbon fluxes and determined the drivers of spatial and temporal variability of oceanic pCO_2. We used a highly resolved dataset of underway pCO_2 measurements from four cruises between June and December 2011. To identify the physical and biological drivers of surface pCO_2 we separated the influence of dissolved inorganic carbon, alkalinity, temperature and salinity on the variability of pCO_2. The results of this study will help clarify the Arctic Ocean's role in the global carbon cycle under future climate change.

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Air Quality assessment of industrial sources on the North Slope of Alaska

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The Alaska Department of Environmental Conservation, Division of Air Quality in managing air quality on the North Slope through its regulatory programs has an interest in developing a better understanding of local air pollution source impacts and the role of industry's cumulative contribution of air pollutants to the atmosphere and their associated transport and fate. The major North Slope industrial sources emit pollutants (i.e., nitrogen oxides, sulfur dioxide, and particulate matter) into the atmosphere along with smaller community based sources of pollution. The cumulative air quality effect of these sources is of interest to North Slope communities, industry and future potential sources. The focus of the project is to conduct an assessment of the North Slope air quality using a dispersion model designed for long range transport and a representative three dimensional meteorological data set of the Beaufort-Chukchi seas and the North Slope. The meteorological data set was prepared by University of Alaska, Fairbanks (UAF) for the Bureau of Ocean Energy Management (BOEM). Accomplishing this task includes using CALPUFF, a regulatory accepted model for assessing the impact of individual sources on air quality. CALPUFF is used routinely for regional haze and NEPA evaluations. We are going to use air quality monitoring and meteorological data sets, and emission information for the year 2009. Expansion of the project to include more North Slope and Outer Continental Shelf (OCS) sources and meteorological data (2005-2008) based on these initial 2009 results will be assessed. The focus of the presentation will be on the initial dispersion model results of several major North Slope sources. The results will be used by the State of Alaska for policy applications related to the cumulative effect of North Slope industrial activity, as a guide to further assessment of the related chemistry and to build upon the existing State and Federal knowledge of permitted onshore and offshore sources. The project will be analyzed in conjunction with other BOEM and other U.S. Federal and Canadian agencies.

Response of the Beaufort shelf and slope to wind forcing for varying ice conditions

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The Alaskan Beaufort shelf is fed by Pacific water emanating from Bering Strait, and is strongly wind-forced in fall and winter due to the passage of synoptic storms. Sea ice tends to be fast on the inner shelf and more mobile farther offshore, modulating the water column response to such storms. Here we use in-situ oceanographic observations from a mooring array that extended from the inner shelf to the continental slope, idealized numerical models and satellite estimates of sea ice drift to characterize the shelf sea ice field and to investigate cross-shelf exchange and water column properties under differing ice conditions. The salinity, temperature and velocity respond strongly to along-shelf winds when the ice cover is mobile everywhere. In contrast, where fast ice is present there is no clear relationship between the ocean circulation and the wind except when along-shelf pressure gradients induced by along-shelf differences in either ice coverage and/or ice mobility induce flow in the direction of the wind. The numerical models are used to supplement gaps in the observational record and together the complementary approaches of modeling and observing are used to assess cross-shelf exchange between the inner and outer shelf and the slope. Satellite data is used to assess long term patterns of shelf sea ice mobility.

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Performance Evaluation of the Chukchi-Beaufort High-resolution Atmospheric Reanalysis (CBHAR)

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The Chukchi-Beaufort Seas region, due to its remote location, complex topography, and highly variable sea ice conditions, represents a particularly difficult environment to accurately characterize, though one that is increasingly important both environmentally and economically. To address these challenges, our project has combined an optimized modeling configuration with the assimilation of quality-controlled in situ and satellite observations to generate the Chukchi-Beaufort High-resolution Atmospheric Reanalysis (CBHAR). This reanalysis describes atmospheric conditions throughout the region for the period 1979–2009 with a grid spacing of 10 km at a one-hour interval. In the current study we extensively evaluated the quality of CBHAR in order to demonstrate its overall performance and thus generate confidence in its use for the wider research community. To do so, the results have been statistically verified against surface station and radiosonde data, both on- and offshore, as well as against QuikSCAT ocean surface winds, in order to provide an overall evaluation of the reanalysis relative to observed conditions. Reanalyzed variables including temperature, dew point, sea level pressure, short- and longwave radiation, and wind speed, direction, and vector were compared to observations from over 200 stations and statistics including root-mean-square error, bias, and correlation were calculated to quantify the performance of the reanalysis. Results were compared to those of ERA-Interim, the global reanalysis used to drive CBHAR. In addition to the overall metrics, seasonal, diurnal, and yearly statistics were calculated in order to evaluate the reanalysis on different time scales, as well as statistics for various groupings of stations in order to characterize its performance across different geographical zones. Improvements over ERA-Interim were found across all time periods, with the greatest benefits observed during winter, and among variables the largest improvements were seen for surface winds, particularly in coastal areas. In addition to the statistical assessment, the ability of the reanalysis to reproduce meso- and local-scale processes, such as the Arctic sea breeze, has been evaluated. It was found that the reanalysis successfully reproduced such circulations with a level of detail not seen in coarser-scale products, demonstrating that CBHAR should serve as a valuable resource for the Arctic research community.

Toward Producing Chukchi-Beaufort High-resolution Atmospheric Reanalysis (CBHAR) via the WRF-Var Data Assimilation System

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The Weather Research and Forecasting (WRF) model and its three-dimensional variational (3DVAR) data assimilation system WRF-Var have been applied to the Beaufort-Chukchi Seas region in order to produce a high-resolution regional atmospheric reanalysis CBHAR as a means of studying the region′s mesoscale meteorology. In order to optimize model performance for the study area, a set of assimilation sensitivity experiments were carried out to analyze WRF-Var sensitivity to model background errors and the success of assimilating various datasets, including in situ surface observations and radiosondes, as well as satellite retrievals of QuikSCAT ocean surface winds and COSMIC and MODIS vertical profiles. All sensitivity tests were forced by the ERA-Interim reanalysis. The observational data were assimilated every 6 hours and the hourly model results were verified against the available observations. In the model background error (BE) data assimilation tests, the results of assimilating in situ surface observations with a customized domain-dependent BE were compared to those with the default built-in BE, demonstrating that the customized BE in general produces better assimilation results. Although an improvement can been seen in both customized and built-in BE tests for surface wind field assimilation, the performance of surface temperature assimilation is more sensitive to the BE selection. When assimilating surface temperatures, model errors are only reduced when using customized BE; assimilation using the default BE magnifies the error. When seasonal variations are incorporated into the customized BE, the impacts are very minor. Sensitivity tests examining the assimilation of different datasets via 3DVAR in WRF demonstrate that: 1) The largest positive impacts are seen through the assimilation of in situ surface and radiosonde observations. Greater improvement can be seen in surface wind field assimilation over both land and ocean; better upper-air temperatures can be found in the radiosonde assimilation; 2) Assimilating QuikSCAT wind data improves the simulation of the surface wind field over the ocean, especially for the wind speed; 3) Selectively assimilating MODIS-retrieved profiles under clear-sky and snow/ice-free conditions can improve the upper-air simulation. Assimilation of COSMIC retrievals only slightly affects upper-air temperatures.

Composition of dissolved organic matter in Arctic sea ice and the underlying water column

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Recent climate change has produced dramatic decreases in the extent and thickness of sea ice in the Arctic. The resulting changes in primary production have altered the concentration of dissolved organic matter in the upper water column and have an unknown impact on the composition of dissolved organic matter in the remaining sea ice. To address this question, sea ice and water samples were collected during a cruise to the Bering, Chukchi, and southern Beaufort seas in the winter of 2011. The organic matter was extracted from the seawater and the molecular level composition of dissolved organic matter assessed using ultrahigh resolution mass spectrometry. The resulting data reveal molecular level differences in the organic matter found in sea ice compared to what is observed in the underlying water column. Furthermore, the dissolved organic matter in sea ice was not linked to that found in the underlying water column indicating selective freezing of organic compounds within sea ice and/or movement of sea ice after its formation. The present project is the first molecular level assessment of the composition of dissolved organic matter in sea ice. These data will be useful in assessing the biological and chemical sinks of organic matter in the Arctic.

Thermal regimes in the Chukchi Sea defined through self-consistent EOF decomposition of the hydrophysical observations since 1941-present and 4Dvar data assimilation

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The summer (June-October) temperature observations in the surface (0-20m) and subsurface (20-bottom) layers in the Chukchi Sea collected since 1941-present have been analyzed through the self-consistent data recovering procedure based on correlation analysis and iterative EOF decomposition. The analysis of the surface (0-20) and subsurface (20-bottom) EOF allowed to identify the typical thermal states (“cold”, “normal”, “warm”) and typical periods of the inter-annual variability which are approximately 7-8 and 2-4 years. We found the water temperature of the Chukchi Sea gradually increase since 1941. The warming in the surface layer is minimal in the Bering Strait (0.8C) and has a strong maximum in the Long Strait (2-2.4C). In the subsurface layer, the increase of the temperature is almost twice as small. It is minimal (0.2-0.5C) in the Long Strait and pretty uniform (0.7-1C) for the remaining part of the Chukchi Sea. The analysis of the satellite sea surface height anomaly data show that during the “warm” periods there is a stronger flow through the Bering Strait and intensification of the northwestward current up to 15-20 cm/s along the Siberian coast towards the Long Strait. The extensive correlation analysis and reconstruction of the circulation using 4Dvar data assimilation show that thermal state of the Chukchi Sea is strongly controlled by flow of the Pacific Water through the Bering Strait and by an increase of the global atmospheric temperature. The reconstructed circulations regimes provide accurate estimates of the volume, heat and salt transports through the Chukchi Sea boundaries.

Interactive Map-based Data Tools for Alaska's Marine Environment

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Advances in research and ocean observing continue to increase our understanding of Alaska′s marine environment. However, to maximize the benefits of these initiatives, a concerted effort is needed to integrate existing data. A variety of factors make data integration challenging – it is collected by a number of entities, housed in dispersed locations, and stored in complex and non-standardized formats. Consequently, existing data is often underused in planning and decision-making processes, or is not available for short term planning and emergency response. To meet these needs, the Alaska Ocean Observing System (AOOS) is actively developing and refining interactive online data tools to assist researchers, regulators, coastal managers, mariners, spill responders, and the general public. This poster will highlight several interactive map-based tools: (1) a Real-time Sensor Map streaming data from over 4,500 real-time sensors statewide; (2) a Model Explorer displaying circulation and other operational models and remote sensing products on a single interface; (3) a Research Assets Map showing the location and type of instruments and monitoring transects conducted by multiple entities; (4) the AOOS Arctic Portal, allowing the overlay of GIS layers, satellite imagery, real-time sensors, and forecast models; (5) the Cook Inlet Response Tool, similar to the Arctic Portal but incorporating special layers such as ShoreZone imagery, videography, and response-specific information. The applications for these types of tools are numerous – from the researcher perspective as well as that of the community or agency manager or planner or other marine user. Current ocean condition information coupled with long-term climate trends and projections can be used to support ecosystem-based management of fisheries and endangered species. Real-time sensor data layered with human use maps and oil spill trajectory predictions could be integral in assisting with spill response. Additionally, much of this information, such as coastline imagery or real-time wind and wave conditions, may be of interest to the general public. An important aspect of these tools is their ability to absorb and reflect increased amounts of data as marine science progresses. The continued development of these portals will be based on new and emerging datasets, as well as user-identified priorities.

Benefits of Being a Student of Teacher Researcher Experiences (SoTRE)

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Mrs. Elizabeth Eubanks is an extraordinary middle school teacher. She participates in activities such as NOAA (National Oceanic and Atmospheric Administration) Teacher At Sea, Polar TREC (Teachers and Researchers & Exploring & Collaboration) and EARTH(Education and Research:Testing Hypothesis). When she goes on these expeditions, she collaborates with real researchers. These programs make her a TRE, which means Teacher Researcher Experience. Her students are called SoTREs. SoTREs are Students of Teacher Researcher Experiences. Mrs. Eubanks has been to Barrow, Alaska (twice) studying carbon fluxes and learning about local research ; is going to Costa Rica in October to work with carbon fluxes; to the Channel Islands in California to study sharks, and Wilmington, North Carolina to learn about real time data- she will also host two courses for educators involving real time data.. She brings back all of the knowledge from her travels with the scientists to her students and community. As SoTREs, we are able to work with real scientists and learn more than what is in the books. For example, while she is away, we are able to read journals, watch video, participate in live webinars and learn about her missions via lessons. With a TRE as a teacher, we get to learn much more than the average class. We are able to work with real scientists and they can even help with some projects we work on. In the end, SoTREs are really privileged and we are able to have a great science experience like ones that will take us to Anchorage, Alaska for the Alaska Marine Symposium- now this is really putting science into live action and experiences.

Late summer near-shore circulation on the western Beaufort shelf and exchange with Elson Lagoon

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Data from current meter moorings on the western Beaufort shelf and in passages to Elson Lagoon show that near-shore currents and exchange between the lagoon and inner shelf are strongly correlated with local winds. Prevailing easterly winds drive the near-shore flow and flow within Elson Lagoon to the northwest. This northwestward near-shore flow is driven off-shelf into Barrow Canyon when easterly wind speeds exceed ~6 m s-1. At intermediate easterly wind speeds, greater than ~ 2 m s-1 and less than ~6 m s-1, the northwestward near-shore flow undergoes retroflection at the edge of Barrow Canyon to flow northeastward. When easterly wind speeds are less than ~2 m s-1 or winds are from the western quadrant, near-shore flow reverses to the southeast.

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Aureophycus aleuticus **Ecological Investigations in Pribilof Domain, Bering Sea, Alaska**

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Aureophycus aleuticus (Laminariales, Phaeophyceae) "Golden V Kelp" thalli were observed growing in Zapadi Bay in July 2008 and initially considered an erratic occurrence of the newly discovered alga. Gross morphology and molecular phylogeny using rbcL DNA sequence matched that of the type specimens from Kagamil Island, the only other reported site globally where this species occurs. Intermittent surveys and ecological investigations were conducted over a five year period in the Pribilof Islands to examine geospatial distribution, substrata and habitat characteristics, response to sea ice, persistence of patches or beds, growth season and rates, reproductive characteristics, effects of herbivory, and other facets of this rare alga's ecology and life history. *Aureophycus aleuticus* is widely distributed around St. George Island, and was not found on St. Paul Island during any survey. Patches ranging from three to dozens of thalli in very high density were adhering to clean rocks and boulders from +0.3 to at least -4.0 meters MLLW. Unlike elsewhere in its distribution, thalli were not observed growing epiphytically. Sporophyte blade linear growth peaked in August, and approximated in situ growth rates for other kelps in Alaska. Some thalli survived more than one year, but whether it is a true perennial remains unconfirmed. Reproductive tissue development begins to appear in September, but spore release timing and gametophyte morphology and habitat are unknown. Echinoderm, mollusk and a single crustacean herbivore were observed grazing on Golden V Kelp blades, often in apparent preference over other algal species in the vicinity. *Littorina spp*. both grazed on Aureophycus and deposited gelatinous egg masses on its blades. Carbon production and habitat value of this species appear to be high in the limited range of its distribution. *Aureophycus* density at Staryartil beach appears to be inversely correlated with sea ice duration and cover. It seems plausible that the species has a competitive advantage over more common Alaria and Laminariales during high ice years, likely due to its ability to colonize and dominate ice-scraped substrata – a result of discoid holdfast size, growth rate and plasticity.

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Development and Analysis of a New Meteorological Database for the Beaufort and Chukchi Seas Coastal Regions

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Meteorological observations were gathered from more than 250 near-surface observing stations throughout Beaufort and Chukchi Sea regions, from Russia to Canada for the period from 1979-2009 for the purpose of validating a newly developed Weather Research & Forecasting (WRF) mesoscale model, which covered the Beaufort and Chukchi Outer Continental Shelf (OCS). Stations included in this database originate from a variety of observing networks operating for the purposes including: aviation, fire weather, coastal weather, climate, surface radiation, and hydrology. Most datasets collected contain observations at hourly or sub-hourly intervals. Three primary quality control (QC) procedures were performed on the data to help assure the quality of the compiled dataset. This was necessary since many of the station′s metadata did not document quality control procedures nor contain QC flags. From this database, eight long term stations were identified as suitable for the development of a climatology representing the 31-year period for temperature, wind speed, and wind direction. As wind fields have received sparse attention historically, the results presented are primarily focused on wind. In addition to the climate analysis, trends were calculated for wind speed and temperature to examine how these variables may have changed over the study period. Climatological results from the observational dataset are directly compared with output from the North American Regional Reanalysis. Strong warming trends were observed at all locations, particularly in climatological Autumn (SON). Significant negative trends in wind speed were observed at several locations, though seasonality was less evident with regard to trends. Performance of NARR when directly compared to observations varied. Temperature was well represented, wind speed and direction less so. Evidence of summertime sea breezes along the North Slope are present in both observational and NARR datasets. Disagreements between modeled data and in-situ observations have been noted in this and other studies focusing on Arctic regions. Thus, the integrated high-resolution dataset compiled here will be invaluable for climate analysis and regional modeling in an area that is undergoing significant change.

Toward a contemporary baseline for zooplankton communities in the American Beaufort Sea

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Zooplankton are major conduits of primary production to higher trophic levels, yet they have been poorly assessed throughout much of the Beaufort Sea. Zooplankton assemblages were characterized for the US Beaufort Shelf as part of a larger multiyear multidisciplinary effort planned for 2010-2014. In 2010-2011, strong cross-shelf gradients were apparent in the zooplankton community, with numerous smaller neritic species giving way to larger oceanic species near the shelf break. Despite the high abundance of the copepods *Pseudocalanus spp*. and *Oithona similis* on the shelf, copepod biomass was dominated by *Calanus* species in both habitats. Predatory biomass was dominated by the arrow worm *Parasagitta* elegans with lesser contributions by the jellyfish *Aglantha digitale*. Our observations are consistent with historic literature, but are establishing the contemporary reference point with which to establish any long-term change in community composition or magnitude.

Maximum Likelihood Ensemble Filter (MLEF) as a potential tool for re-analysis and operational hind-cast in the Arctic Ocean

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The MLEF is an efficient ensemble approach for assimilation of data into a model. The algorithm is based on a combination of the Ensemble Kalman Filtration (EnKF) and 3D variational (3Dvar) data assimilation approaches. As in these methods, the cost function derived within the framework of Gaussian probability distributions. Like other ensemble data assimilation algorithms, the MLEF is able to produce an estimate of the analysis uncertainty and does so at low computational cost. We illustrate performance of the MLEF in a series of data assimilation experiments using a community ocean model (ROMS) and discuss the potential advantages of this new data assimilation approach as a powerful tool for re-analysis and operational hind-cast.

Understanding Extreme Weather Events and Their Impacts on Surface Wind and Sea Ice in Chukchi-Beaufort Seas

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Long-term changes in weather patterns and surface winds have been detected over the Chukchi-Beaufort Seas through the use of the newly-developed Chukchi-Beaufort High-Resolution Atmospheric Reanalysis (CBHAR). Embedded within these long-term changes, it has been noted that extreme weather events have occurred with increasing frequency in recent years. To understand the physical mechanisms and impacts of these extreme events, we have investigated two particularly unusual storms in this study. The first storm occurred during 23–30 September 2010, showing unusual persistence and lingering over the Beaufort Sea for more than five days. The other occurred during 5–9 August 2012, exhibiting extremely strong intensity with a minimum central surface pressure of 964 hPa on 6 August. The presence of the former storm resulted in persistent northerly winds that favored a southward extension of the ice edge, resulting in enhanced sea ice coverage in the Northern Beaufort Sea. The wind pattern associated with the August storm brought southwest winds into the Beaufort Sea, an anomalous wind pattern that enhanced warm air transport into the area and contributed to a rapid retreat of sea ice cover.

Assessing qualitative variability of phytoplankton biomass and community structure in the Pacific-Arctic Region based on pigment analysis

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Marine phytoplankton provide an important sink for atmospheric carbon dioxide (CO2) and are a principal part of the global carbon cycle. The rate of CO2 uptake during photosynthesis by these organisms is controlled by a number of factors, including community composition within phytoplankton groups. In 2012, the Chukchi Sea Environmental Studies Program (CSESP) added a new task to collect data on community structure and distribution. We will present new data collected in 2012 from the western Arctic Ocean and the Northern Gulf of Alaska to help assess the spatial and long-term variability in phytoplankton distributions in these regions, particularly in the context of changing climatological conditions. Using data from High Performance Liquid Chromatography (HPLC) analysis we will describe individual pigments, which provide qualitative information on the phytoplankton groups. This data will then be used to compare the similarities and differences in community structures and rates of primary production in the polar arctic seas with the more temperate waters of the northern Gulf of Alaska.

Modeling seasonal variations of sea ice and plankton in the Bering and Chukchi Seas during 2007-2008

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A six-compartment ecosystem model coupled to an ice-ocean model was applied to the Bering and Chukchi Seas during 2007-2008. The model reasonably reproduces the seasonal cycles of sea ice, phytoplankton, and zooplankton in the Bering-Chukchi Seas. The spatial variation of the phytoplankton bloom was predominantly controlled by the sea ice retreat or the increase gradient of the water temperature from the south to the north. The model captures the basic structure of the measured nutrients and chl-a along the Bering shelf during July 4-23, 2008, and along the Chukchi shelf during August 5-12, 2007. The model and the data reveal complexity of the lower trophic dynamics in the Bering and the Chukchi Seas. In the summer 2008, the Green Belt bloom was not observed by either the satellite measurements or the model.

Using in situ observations to validate the performance of a high-resolution global model in the Bering, Beaufort and Chukchi Seas

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The Bering Strait – the only connection between the Pacific and Arctic Ocean – is a "choke point" for global ocean circulation that is not well resolved in many global models. Regional models often do not have a large enough domain to encompass throughflow sources and destinations. We use observations available from across the Bering, Beaufort and Chukchi Seas to make point-to-point comparisons with model output from high-resolution MITgcm/ECCO2 integrations. These observations include seven instrumented sub-surface moorings spread across the 85-km wide Bering Strait (T,S and velocity at near-bottom and mid-depth), an array of six sub-surface moorings located at the mouth of Barrow Canyon (T,S and velocity), high-resolution CTD data from autonomous underwater vehicle missions, and high-frequency 2D surface current data from coastal HF radar systems spanning the North-eastern part of the Chukchi Sea. This wealth of data is used to analyse the performance of global MITgcm model calculations, which generally show consistency with the observed data sets. For example, long-term seasonal cycles of T and S in the Bering Strait correlate well ($R > 0.8$, $p < 0.05$), and mean model velocities agree well with observations. The validation of the model calculations suggests that the model can be used with confidence to augment the existing observations and lead to more complete understanding of ocean circulation and associated dynamics in these important high-latitude areas.

Arctic – Climate and Oceanography

Arctic Rediscovery: Providing access to heritage data resources for climate and ecosystem research

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The purpose of the Arctic Rediscovery Project is to recover millions of weather and environmental records currently in manuscript form and convert them into digital formats that can be integrated into large-scale data sets for analysis. This data is needed for scientists to better understand longer-term environmental variations in the Arctic and is vital to our efforts to model and predict future change and its human impact. A huge amount of new-to-science data is contained in ship logbooks and other original documents that have been preserved by the U.S. National Archives (and other repositories) for generations. This project provides access to this data through collaboration between NOAA, the U.S. National Archive and Records Administration (NARA), and thousands of citizen volunteers participating in the Old Weather project. The Arctic Rediscovery website website describes the project and includes example images of original log books, sea ice maps from the Danish Meteorological Institute, a bibliography, YouTube videos, and a gallery of photographs with fascinating details of life on historical ships to augment the data being recovered from the ships logs. The website also describes a number of supporting projects set up with library science/informatics students. See http://www.pmel.noaa.gov/arctic/rediscover/. The weather and climate data extracted from manuscript logbooks will be incorporated into existing or new climate datasets such as the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), for example, and will provide the observations needed to produce globally comprehensive long-period reanalysis datasets like the Twentieth Century Reanalysis (http://go.usa.gov/XTd). In addition to environmental data a vast quantity of historical information will also be made accessible to researchers and the general public. Original documents will be viewable on the National Archives website (http://www.archives.gov). After Old Weather transcription (http://www.oldweather.org), new search and visualization techniques can be applied to this resource that will draw out the stories that connect people of today to the places and people important to their own communities and families in the past. Support for the Arctic Rediscovery Project is provided by North Pacific Research Board (NPRB). Many partners and collaborators have made indispensable contributions to the project.

Establishment of an Optimized Regional Modeling System for the Chukchi-Beaufort High-Resolution Atmospheric Reanalysis (CBHAR)

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One of the foremost challenges when establishing a regional model such as the Weather Research and Forecasting (WRF) model for use in a particular region is the determination of the most appropriate model physics. Different regions experience varied conditions and present unique problems, and the optimal setup for one area may not necessarily be applicable to another. This is especially true in the Arctic, which presents many unique modeling challenges that parameterizations developed for and primarily tested in the mid-latitudes may be unable to adequately address. To address this challenge, we conducted extensive model sensitivity tests to optimize the WRF model physics configuration for application in the Beaufort-Chukchi Seas region. Model physics parameterizations, including those for shortwave and longwave radiation, microphysics, planetary boundary layer (PBL), and land surface processes were tested. The sensitivity simulations were verified against a quality-controlled observational database specifically developed for the study area. The testing period chosen was September 2004, which represents the transition from summer to winter in the study region and includes sea ice growth and periods of both bare ground and snowcover. A synthesis of the sensitivity results resulted in the following model physics configuration for CBHAR: NOAH land surface model, MYJ TKE PBL, RRTMG longwave and shortwave radiation, double-moment Morrison microphysics, and Grell 3D ensemble cumulus. The second critical effort involved in this study was to further improve the existing WRF model physics. Up to this point, sea ice, an important geographic feature in our study area that plays a significant role in the surface energy budget and momentum transfer via its unique surface characteristics of roughness, albedo, and heat conductivity, had been treated as just another land cover type within WRF. Without sufficient complexity, its thermodynamic and dynamic effects are difficult to adequately characterize. To address this deficiency, we have coupled a thermodynamic sea ice model with WRF in order to improve the model′s simulation of sea ice surface conditions. The coupled model was tested and verified against Surface HEat Budget of the Arctic (SHEBA) field measurements and the results demonstrated significant improvements in simulating surface thermal conditions.

Arctic - Lower Trophic Levels

Year-to-year variability of krill abundance at a bowhead whale feeding hotspot near Barrow, AK: 2005-2011

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The shelf near Barrow, AK is a feeding hotspot for the bowhead whale during the whales' fall migration from the Canadian Arctic to the Bering Sea. The oceanographic conditions producing this hotspot and interannual variability in biological and physical ocean conditions near Barrow have been documented from 2005-2012 as part of an ongoing study. Multiple water masses were observed each year and the overall physical conditions in the region were related to the larger scale meteorological patterns and dominant wind direction. Short-term variability in conditions on the shelf, including plankton abundance and composition, was intimately tied to the direction and strength of the local winds. In particular, high concentrations of euphausiids/krill were found on the shelf in response to shelfbreak upwelling of water and krill forced by east winds that were followed by south or weak winds that moved the Alaska Coastal Current against the eastern wall of Barrow Canyon, trapping and concentrating the upwelled krill on the shelf. The frequency of occurrence of this mechanism varied interannually, with the most days observed in 2010 and 2011. The abundance and relative proportions of larger adult and juvenile krill vs. krill furcilia also varied interannually and likely were related to larger scale patterns in krill abundance and transport from the Bering Sea.

Trophic structure of benthic primary consumers on the U.S. eastern Beaufort Sea shelf

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In light of current oil exploration pressure and warming trends in the Arctic, developing a baseline for the trophic structure of the hydrographically complex, but little explored, Beaufort Sea shelf is a critical anticipatory step in gauging future anthropogenic or natural changes to the system. The typically tight trophic coupling between primary productivity and benthic communities that is present on many Arctic shelf ecosystems may be disrupted in the eastern Beaufort Sea by the substantial freshwater influence of the McKenzie River. This river influence also adds a terrestrial carbon source to the marine food web, in addition to sea-ice associated algae or open-ocean phytoplankton. We used stable isotope analysis both to illuminate the relative trophic position of each species in a system as well as distinguish the origin of the primary nutrient source for the food web. As part of the BOEM-funded U.S.-Canada Transboundary project, we collected water column particulate organic matter (POM), zooplankton, sediment and benthic invertebrates for stable isotope analysis across the eastern Beaufort Sea from 20 – 1000 m depth in September 2012. This poster presents the first results concerning spatial and depth gradients in isotopic composition of POM and benthic primary consumers, providing an initial picture of lower trophic community structure in the eastern Beaufort Sea.

Arctic - Lower Trophic Levels

Topographic Control on Macrobenthic Community Structure in the Northeastern Chukchi Sea

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Benthic communities were sampled as part of the interdisciplinary Chukchi Sea Environmental Studies Project (CSESP) conducted during the 2011 open water season to evaluate benthic community structure and environmental characteristics in a large study area in the northeastern Chukchi Sea. The study area included three proposed oil and gas exploration areas (Burger, Klondike, and Statoil) and Hanna Shoal and encompassed four strata: South (containing Klondike), Central A (containing Burger), Central B (containing Statoil), and North (encompassing Hanna Shoal). Benthic macrofauna were sampled with a van Veen grab and megafauna were sampled using digital photography. Habitats varied from mud with sporadic rock in Klondike, to muddy sediments in Burger and Statoil, to sand at Hanna Shoal. Macrofaunal density and biomass were lower in the South and North with biomass highest in the Central A stratum. Bivalve biomass and density were highest in the Central A and B strata, whereas polychaete density was highest in the Central A stratum and biomass highest in the South stratum. Multivariate statistical analysis demonstrated associations of macrofaunal community characteristics with water depth, sediment organic carbon, sediment grain-size, and bottom-water temperature reflecting the topographic features and oceanographic trends driving carbon availability and community structure. The increased bivalve biomass occurred in a deeper area with colder bottom-water temperatures. Megafaunal communities varied with substrate with upright epibiota present on the rocks in Klondike, brittle stars dominant in Burger and Statoil, and epibiota in sand substrates near Hanna Shoal. Overall, interactions between seafloor topography and water currents resulting in increased deposition of carbon appear to be driving forces for the differences in biomass and density in macrofaunal communities. The distributions of megafaunal communities were also related to carbon availability shifting from suspension-feeding, upright colonial forms where currents and hard substrates are available to deposit-feeding and predatory forms in muddy sediments.

Data rescue: Epibenthic invertebrates from the Beaufort Sea sampled during WEBSEC and OCS cruises in the 1970s

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A major challenge in climate- and human impact-related studies is the lack of historical data against which to assess biological response to changes and stresses in the environment. This ongoing work seeks to rescue data on epibenthic invertebrates sampled by trawls in the Alaskan Beaufort Sea during Western Beaufort Sea Ecological Cruises and Outer Continental Shelf cruises in the 1970s. To date, a geo-referenced presence/absence data matrix of faunal distribution records was compiled for 210 taxa (mostly species level) at 23 sites from maps in print-only reports. Approximately 60 of those taxa were primarily infaunal. Of the remaining epifaunal species (the target group of trawls), the majority were crustaceans, followed by mollusks and echinoderms. Occurrences of some phyla were not listed in the available sources such as Porifera and Cnidaria. Holothuroid and ophiuroid material from Carey's work, archived at the Natural History Museum of Los Angeles County, is under investigation and suggests that *Myriotrochus rinkii* and *Psolus peronii* were the most common sea cucumbers in the US Beaufort Sea in the 1970s. The taxonomic inventory resulting from this work was combined with Carey's macrofaunal inventory and reconciled to the World Register of Marine Species. The number of all taxa combined amounted to 1026. The taxonomic inventory and distribution data can form a reference point for the 1970's for future comparisons to surveys in the Beaufort Sea done in/planned for 2008 and 2011-2014.

Population assessment of snow crab, *Chionoecetes opilio*, in the Chukchi Sea: preliminary findings

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Little is known about the occurrence and stock characteristics of snow crab, *Chionoecetes opilio*, in the Arctic including the Chukchi Sea. Climate warming might result in a range shift or extension of the species with potential fisheries implications. Snow crabs were therefore collected for a population assessment of the Russian and US Chukchi Sea shelf in Aug/Sept of 2009, 2010 and 2012 using small beam and otter trawls. Snow crabs were found at almost all locations sampled, as far north as Wrangell Island in the northwest and into the Beaufort Sea to the east. Chukchi Sea crabs were overall smaller than in the Bering Sea with a size from 4-73 mm carapace width (CW) and the vast majority <55 mm CW. Sex composition and spatial distribution of mature females and juvenile crabs varied between years although the survey areas for 2009 and 2012 were largely identical. In 2009, the vast majority of crabs were male and immature females, mostly new shell with little epi-growth. In 2012, mature females and males were collected in similar numbers, and several sites with crabs <15 mm CW were encountered. Mature females ranged in size from 34-63 mm CW and occurred through the study area. Most mature females found had full clutches and eggs were mostly in the earliest stages of development. Egg counts resulted in fecundity estimates of 4,946-53,351 eggs per clutch with a mean of 18,671. Egg counts were correlated with body size of mature females. The data suggest that local reproduction occurs in the Chukchi Sea, but individuals do not reach commercial size classes.

Inter-annual variation in the spatial patterns of *Pseudocalanus* species distribution and egg production

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Pseudocalanus spp. are among the most important components of the Chukchi Sea zooplankton, accounting for up to 60% of total copepod abundance and up to 20% of the total zooplankton biomass. Species-specific egg production rates for the three species present were estimated throughout the studied region, from the Bering Strait northward to Wrangel Island, for the years 2004, 2009 and 2012. Different water masses were characterized by different species composition, with *P. newmani* dominating in warmer Bering/Pacific waters and the larger bodied *P. acuspe*s and *P. minutus* being characteristic for the colder Arctic waters. Inter-annual variation in the water mass distribution was reflected in the distribution of *Pseudocalanus spp*. Where co-occurring, the species show comparable mass-specific egg production rates across the studied range; the observed values were similar in 2004 and 2012 and slightly lower in 2009. Ecological implications for species-specific and interannual variation are discussed.

Habitat Heterogeneity and Gear Efficiency for Epifauna in the Northeastern Chukchi Sea

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As part of the interdisciplinary Chukchi Sea Environmental Studies Project (CSESP), video surveys were conducted during the 2011 open water season to evaluate habitat variability and benthic communities in a large study area in the northeastern Chukchi Sea encompassing three proposed oil and gas exploration areas (Burger, Klondike, and Statoil) and Hanna Shoal. The study area was divided into four strata: South (containing Klondike), Central A (containing Burger), Central B (containing Statoil), and North (encompassing Hanna Shoal). Habitat type and benthic community composition were visually sampled at 33 sites with a high definition digital camera. At 12 sites, the seafloor was surveyed at 0, 50, 100, 250, 500, and 1000m along one kilometer transects to assess small scale variability. Benthic sediments varied on small and large spatial scales. On a regional scale, the South stratum was highly variable ranging from mud interspersed with gravel and rock; Central A and B were predominantly mud; the North had equal occurrences of sand and mud with coarser sediments intermixed. Along one kilometer transects, habitat variability mirrored patterns seen at the regional scale. Benthic community composition, both epifaunal and near surface infaunal organisms, corresponded with sediment characteristics. More upright, suspension feeding organisms were present on the rocky areas found in the South stratum; deposit feeders such as brittle stars dominated the muddy Central A and B strata; the sandy North stratum supported few organisms. During the 2008-2011 CSESP, benthic communities were sampled by three methods: van Veen grabs, bottom trawls, and video surveys. Each method targeted different components of the benthos and had varying sampling scales, but all overlapped in what organisms were actually collected. Comparisons of catch data of dominant megafauna suggest that bottom trawls underestimate brittle star densities where they are abundant, while van Veen grabs collect fairly representative samples. Re-evaluation of sampling efficiency for targeted taxa may lead to less invasive surveys.

COMIDA: Efforts towards building a long-term time series for epibenthic communities in the Chukchi Sea

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Long-term data sets are valuable for examining ecological changes in community structure. Determining if changes have occurred and what has changed can be of assistance in guiding future research. Although long term epibenthic data sets in the Arctic are rare, much may be gleamed from precise locations that are revisited over time. Three stations in the Chukchi Sea were trawled with the same gear in August 2009, 2010, and 2012. Proportional taxa composition, abundance, and biomass were compared and found to largely vary over time, with some taxa increasing while others decreased. Size frequency of one species, the snow crab *Chionoecetes opilio*, was also found to vary over time, with many small recruits found in 2009, followed by fewer and larger individuals in 2010 and 2012. Continuation of monitoring at these sites and others where previous data have been accumulated should be a priority in our changing and developing arctic seas.

Arctic - Lower Trophic Levels

Epibenthic Community Structure of Hanna Shoal in the Chukchi Sea, Alaska

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Epibenthic communities have a wide range of organisms from highly motile individuals such as crabs, to sessile forms such as colonial hydroids. These communities serve an important role in the ocean environment as a major food source for marine mammals and fish, and also contribute to overall benthic production. Arctic marine systems have the potential to undergo changes due to climate variability, and in some places because of oil and gas development. One such system is the epibenthos of Hanna Shoal in the Chukchi Sea. This is a highly productive region, with high benthic invertebrate biomass and abundance. The goal of this study is to describe the epibenthic community of Hanna Shoal, and to compare this with adjacent off-shoal areas. Our hypothesis is that we will find a higher epibenthic invertebrate biomass and abundance on the shoal versus off the shoal. A plumb staff beam trawl was used to assess epibenthic biomass, abundance, species composition, and size distributions of dominant invertebrate taxa at six stations on Hanna Shoal, and another 16 stations adjacent to the shoal. In general, we observed 93 taxa and counted 126,427 organisms with a total biomass of 209.301 kg. These data will help us determine the biomass and abundance per area on Hanna Shoal vs. off the shoal. The communities were found to have patchy distributions, with the dominant species and their relative sizes changing among stations and on and off the shoal. This analysis is the first step in 1) obtaining a detailed epibenthic description of Hanna Shoal, 2) comparing this Hanna Shoal with adjoining regions, and 3) determining the role Hanna Shoal plays in this region.

Arctic - Lower Trophic Levels

Distribution of *Pseudocalanus spp*. in the Pacific-Arctic as revealed by molecular markers

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Pseudocalanus (Copepod, Calanoida) are one of the most dominant genera in Arctic and sub-Arctic waters, and with current warming trends are anticipated to expand their range further north into the Arctic Basin. However, *Pseudocalanus* present taxonomic difficulty in morphological identification down to the species level, and thus detailed specie-specific distribution data is lacking for this genera. We sequenced the mitochondrial gene cytochrome oxidase I (mtCOI) from four sibling species *of Pseudocalanus* (*P. acuspes, P. minutus, P. mimus and P. newmani*) to determine presence, distribution and population genetic structure within North Pacific and Western Arctic waters. We present our results for the Pacific-Arctiv region, and speculate on how faunal boundaries may shift under climate change scenarios.

Alaskan Arctic shelf epibenthic communities: A tale of two seas

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Epibenthic organisms can occur in large numbers and high biomass on the Alaskan Arctic continental shelves. From an ecosystem perspective, epibenthic organisms are important in recycling and redistributing organic matter deposited from the pelagic zone, and they also are key members of the local food web. Invertebrate biomass, abundance and taxon composition were analyzed from 125 stations sampled in 2009, 2010, and 2011 in the NE Chukchi and Alaskan Beaufort Seas using epibenthic trawls. This analysis compared the epibenthic communities across the two regions, focusing on changes in biomass, abundance and taxonomic dominance. Most stations in the Chukchi sea region had a higher biomass and abundance than the Beaufort Sea region. The higher biomass stations of both regions were the ones closest to Barrow Canyon. This also held true for the higher abundance stations; however a group of high abundance stations was also present at the eastern end of the Beaufort Sea study area. In terms of abundance and biomass, *Ophiuroidea, Chionoecetes opilio, Caridea, Pagurus spp. and Saduria spp.* were selected as important representatives of the community across both regions. Also across regions, stations appeared to cluster by water depth, especially at the mid and deeper depth category, resulting in a higher similarity between Beaufort Seas deep stations and mid-depth Chukchi Sea stations. The dissimilarities observed in the epibenthic biomass, abundance and taxon composition of these two regions highlight the differences in the physical environment and processes that take place across regions.

Zooplankton in an arctic under change: communities of the Canada Basin

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The one to two year life cycles of Arctic zooplankton make them ideal candidates to explore the effects of the rapidly changing arctic environment over the past decade. The species composition, abundance, and biomass of the zooplankton community were analyzed using samples captured by 150 μm nets in the upper 100 meters of the water column from the Canada Basin during August of 2003 to 2006. We confirm that the most abundant zooplankton species throughout the years were the smaller copepod species such as *Oithona similis* and *Microcalanus pygmaeus*. However, these species contributed relatively little to the biomass compared to larger copepod species such as *Calanus hyperboreus and C. glacialis*. For the non-copepod herbivorous zooplankton, the pteropod *Limacina helicina* and the larvacean *Fritillaria borealis* were the most abundant species, but showed considerable variability between years in importance. The non-copepod predatory biomass was dominated by the arrow worm *Eukrohnia hamata*, the jellyfish *Aglantha digitale*, and *Themisto hyperiid* amphipods. We discuss the magnitude of inter-annual variability, and address to what extent long-term community change can or cannot be detected.

Caloric Content of Infaunal Communities in the Northeastern Chukchi Sea

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As part of the interdisciplinary Chukchi Sea Environmental Studies Project (CSESP), benthic fauna were sampled during the 2011 open water season to evaluate associations between habitat variability and caloric content in a large study area in the northeastern Chukchi Sea encompassing three proposed oil and gas exploration areas (Burger, Klondike, and Statoil) and Hanna Shoal. The Chukchi Sea shelf is a highly productive region that supports a large benthic biomass and abundance as low zooplankton grazing rates allow for more organic carbon to settle to the seafloor, resulting in strong pelagic-benthic coupling. The energy (caloric) content of organisms is important for many predators and for energy flow through the food web. Prior studies assume that caloric content for organisms are constant but this might not be true as caloric content can covary with spatial variations in environmental characteristics. This study determined how caloric content for individual organisms varied within the CSESP regional study area and determine which environmental variables were associated with this variation. The environmental variables used for this study included sediment grain-size, sediment organic carbon, chlorophyll a, and water depth. Fauna were collected via van Veen grab organisms then sorted into the following groups: *Astarte borealis*, *Macoma calcarea*, *Golfingia margaritacea*, Maldane sarsi, *Ennucula tennuis,* Polychaeta, Bivalvia, Amphipoda, and others. The caloric content of the dominant and aggregated taxa are compared between strata (Southl, Central A, Central B, and North) to determine the spatial distribution of caloric content for macrofauna within the northeastern Chukchi Sea. Associations with environmental variables were evaluated using multiple linear regression models to determine significant predictors of caloric content of individuals and of the community. Previous analysis of energy density of *Ennucula tenuis* and *Macoma*, based on weight to energy conversions, show a trend of increasing caloric content towards Burger and towards eastern Hannah Shoal. We predicted that spatial models of caloric content for individuals and the whole community covaried with environmental characteristics rather than differences in biomass alone.

Contribution of sea ice algae to two benthic feeding guilds on the Chukchi Sea shelf

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The two main sources of primary production in Arctic waters are sea ice algae and open ocean phytoplankton. The ongoing reduction of seasonal sea ice coverage in the Chukchi Sea due to climatic changes could shift the contribution of primary production increasingly towards open ocean phytoplankton. This shift may affect benthic organisms on the Chukchi shelf that are dependent on an early food pulse from sea ice algae. We use compound specific stable isotope analysis of polyunsaturated fatty acids (PUFAs) to determine the contribution of sea ice algae to two representative functional feeding groups of the benthic community, filter-feeding bivalves and the omnivore snow crab *Chionoecetes opilio*. The PUFAs used in this study are 16:4(n-1) and 20:5(n-3) (eicosapentaenoic acid). Sampling of the two groups was conducted in August/September 2012 along a latitudinal gradient of sea ice cover in the Chukchi Sea as a proxy for the loss of sea ice. Here we present a conceptual approach to test the hypothesis that primary consumer bivalves have higher contributions of sea ice algal-derived PUFA in their body tissues in the northern than the southern Chukchi Sea, while no differences occur in the omnivorous *C. opilio*.

A preliminary temporal comparison of epibenthic communities and benthic food web structure in the southern Chukchi Sea (2004, 2009, 2012)

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The Chukchi Sea shelf ecosystem is a benthos-dominated system in an area that is undergoing substantial climate change. In that area the Russian-American-Long-term-Census-of-the-Arctic (RUSALCA) aims at building a time series of data on environmental and biotic conditions. Within that program, we use benthic food web structure and epibenthic community structure to track potential environmental changes in the system, and this poster presents a preliminary temporal comparison of those ecosystem components between 2004, 2009 and 2012. Total epifaunal abundance, biomass and relative contributions of dominant phyla to standing stock varied greatly among the eight time series locations and among the three sampling years with no unified pattern for all sites. Averaged across sites, however, total epifaunal biomass increased from 2004 to 2009 and decreased from 2009 to 2012, with levels remaining higher than in 2004. The average relative contribution of Arthropoda (primarily Crustacea) to total abundance and biomass increased over the sampling period while the relative contribution of Echinodermata decreased. These two groups used to make up the majority of total standing stock, but the relative contribution of Molluska surmounted that of Echinodermata in 2012. The $\delta^{13}C$ signature of particulate organic matter food source for the benthos was similar in Alaska Coastal Water sites in all three years with evident terrestrial influence. In contrast, $\delta^{13}C$ was comparatively more enriched in 2004 and 2012 in Anadyr Water sites, reflecting a more marine carbon signature. No changes in trophic position of benthic fauna, based on $\delta^{15}N$ ratios, were found between 2004 and 2009, with 2012 samples awaiting analysis. The observed regional and interannual variability stress the need for long-term time-series to identify trends beyond decadal scales.

ShoreZone in the Arctic – 8,000 km of Coastal Habitat Mapping

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ShoreZone coastal habitat mapping is being conducted along 8,000 km of arctic shoreline, stretching from Cape Prince of Wales in the Bering Strait to the Canada - US border in the Beaufort Sea. Mapping interpretations following the ShoreZone mapping protocol are based on a variety of imagery sources ranging from 2001 NOAA videography to 2012 imagery collected specifically for ShoreZone. The ShoreZone protocol has been revised to incorporate periglacial landforms and arctic coastal biota (Harper and Morris 2011). Over 60 ground stations provide high-resolution detail to support and to validate the mapping interpretations. The extensive dataset will provide a continental-scale characterization of the arctic shoreline and support planning efforts related to oils spills, coastal development, and climate change. Web-posting of aerial imagery provides an operational planning tool for site-scale issues whereas the regional mapping data (e.g., occurrence of salt marsh habitat) provides a tool for large-scale planning issues. A coastal hazards map for selected areas will identify locations most sensitive to erosion, thaw subsidence, and storm-surge/sea-level-rise inundation. Project support is provided by the Bureau of Ocean Energy Management (BOEM), National Park Service (NPS), Arctic Landscape Conservation Cooperative (ALCC), Western Arctic Landscape Conservation Cooperative (WALCC), Alaska Department of Natural Resources, and NOAA Fisheries (Auke Bay Laboratories and Alaska Regional Office).

2011 Fish and Invertebrate Trawl Surveys in the Chukchi Sea Environmental Studies Program

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A survey of fish and invertebrate resources was completed in the northeastern Chukchi Sea from 24–31 August 2011 as part of the Chukchi Sea Environmental Studies Program (CSESP). The survey deployed pelagic and bottom trawls within a study area ~11,000 NM2 in area, with higher sampling effort focused on three study-area boxes (oil lease blocks) located near Hanna Shoal between Pt. Barrow and Pt. Lay. A 60-ft steel trawler conducted pelagic trawling at 19 stations on 24–28 August, followed by bottom trawling at 19 stations on 29–31 August. Tow durations for the bottom- and pelagic-survey trawl gear were ~15 min and ~30 min, respectively. Biomass estimates for the three most abundant species (snow crab *Chionoecetes opilio*, Arctic lyre crab *Hyas coarcticus*, and Arctic cod *Boreogadus saida*) caught in the bottom trawl (excluding brittle stars and other sea star species) were low ranging from about 2,000 to 65,000 MT (0.5–17.5 kg/ha). The density of fish and invertebrates was higher in the southwestern and central parts of the study area than in the northeastern part of the study area. Pelagic trawl catches were less diverse than were bottom trawl catches and indicated that the density of three small pelagic species – Arctic cod, Pacific sandlance, and capelin - was low, ranging from 0 to ~3,000 individuals/tow. Catches from the bottom trawl showed lower densities of Arctic cod but more variety of demersal fish species, including sculpins, eelpouts, snailfishes, and wolffish. High densities of snow crab, especially in the southwestern part of the study area, were the only significant catches from the bottom trawl with current potential commercial value. Estimates of total abundance and biomass of fish species encountered in the 2011 fish surveys were low. Catch rates of key species were similar to or lower than other surveys of the northeastern Chukchi Sea study area and are considerably lower than catch rates for surveys in adjacent areas (Arctic Ocean, northern Bering Sea). In addition, species diversity appears to be low, and individuals in catch were small and below normal sizes for commercial exploitation.

The diets of three demersal fishes inhabiting the Beaufort and Chukchi Seas

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As agencies increase efforts to integrate ecosystem-wide information into management and policy, the continued collection of baseline, ecological information of organisms inhabiting oil lease sale areas in the Arctic is needed to understand the present relationships between trophic levels. Arctic cod (*Boreogadus saida*), Arctic staghorn sculpin (*Gymnocanthus tricuspis*), and shorthorn sculpin (*Myoxocephalus scorpius*) are abundant in the Chukchi and Beaufort Sea ecosystems. Food habits studies of Arctic marine mammals indicate the importance of these fishes as a dietary source; however, less is known about the diets of these fishes and their place in the Arctic food web. This project examines the food habits of *B.saida*, *G. tricuspis*, and *M. scorpius* within the Beaufort and Chukchi Seas in order to quantify diet differences and identify present relationships between fishes and their prey. Diets were examined using percent weight (%W), percent number (%N), and percent occurrence (%O). Data analyses and comparisons were completed using general linearized modeling and multi-dimensional scaling approaches. Preliminary %O results highlighted a marked difference in resource use between *B.saida* and the two sculpin species. *B. saida* showed a strong reliance upon calanoid copepods, *Calanus glacialis*, and *C. hyperboreus*. Other frequently occurring prey items included, hyperiid amphipods (*Themisto sp*.), euphausiids (*Thysanoessa sp*.), and unidentifiable crustacean fragments. In *G. tricuspis* and *M. scorpius* diets, %O values indicated gammarid amphipods, *Ischyocerus sp.,* and *Protomedeia sp*. were important to both diets; however, *M. scorpius* included a greater amount of fish (Cottidae) and crabs (*Paguridae* and *Chionocetes sp*. megalops) than did *G. tricuspis*. Information gained from this study should shed light on which prey resources are most important to each of these three fish species furthering the available knowledge on trophic interactions in the Beaufort and Chukchi Seas.

A comparison of nearshore kelp habitats across the Alaskan Arctic coast – an Ocean Exploration project

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Rocky habitat dominated by kelps is rare in the nearshore Arctic, but where they occur these habitats are known to be distinct biodiversity hotspots. These boulder regions are ecologically important because they support benthic primary producers with tightly linked food webs. Here we present the results on the exploration of a new boulder field in the coastal Chukchi Sea near Barrow, including a first quantitative biological description of this boulder community. We also compare this community to other such kelp communities in the coastal Beaufort Sea. Our results show that these nearshore boulder communities along the Alaskan Arctic shore share many of their community elements but that each community also has dominant members that are infrequent at the other locations. This indicates that dispersal and exchange among these communities may be limited and a substantial amount of local recruitment may occur.

Arctic - Fish and Fish Habitat

Offshore Marine Fishes in the Canadian Beaufort Sea – initial findings and future directions

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Fisheries and Oceans Canada (DFO), Central and Arctic Region, conducted the first ever deepwater baseline survey of fishes and habitat parameters in the offshore Canadian Beaufort Sea between August 5th and September 3rd, 2012, as part of the Beaufort Regional Environmental Assessment (BREA). The 2012 program also marked the first of a three-year collaboration with the US Bureau of Ocean Energy Management (BOEM), and the University of Alaska Fairbanks (UAF), aimed at integrating methods and results from concurrent research programs in both countries to gain a better regional understanding of the Beaufort Sea ecosystem. The fishing vessel Frosti was used to sample four primary transects, each with stations at 40, 75, 200, 350, 500, 750 and 1000 m depths. Fishes were collected with two types of nets; a modified Atlantic Western IIA (WIIA) benthic trawl and a Cosmos-Swam 260m mid-water trawl. Pelagic fishing was conducted in conjunction with hydroacoustic data collection. A suite of habitat and foodweb parameters were also sampled at each station including: oceanography, water chemistry, benthic fauna, sediment characterization, zooplankton, bacterial and primary production. Initial results indicate a distinct shift in fish community structure beyond 200m depth including a large near-bottom aggregation of Arctic Cod (*Boreogadus saida*) starting at approximately 200m depth and extending down slope to 400m. Beyond approximately 400m bottom depth, a target layer persisted in the water column, within the same depth range. Additional investigations showed that this aggregation occurred along the entire Canadian Beaufort Sea Shelf. This study documented several new species' occurrences in the Canadian Beaufort Sea and, in combination with the knowledge of Arctic Cod, results will significantly improve our understanding of fishes in the Beaufort Sea. Knowledge regarding Arctic Cod may also help to answer questions in regards to sufficient food base for higher trophic levels (e.g., birds, seals, whales).

Arctic - Fish and Fish Habitat

Pan-Arctic genetic population structure of the Arctic Cod *Boreogadus saida*

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The arctic cod, *Boreogadus saida* is of high ecological importance and management concern. Genetic analysis can provide insight into important aspects of the biology and biogeography of this foundational species. Here we report analysis of the genetic population structure of *Boreogadus saida* working with samples collected from the western North Atlantic to the eastern North Pacific as well as the Laptev and Greenland seas. As previously reported, analysis of microsatellite DNA variation showed differentiation between specimens sampled in eastern (Baffin Bay, Trinity Bay and the Gulf of St. Lawrence) and western regions (Chukchi, Bering and Beaufort seas) and additional samples analysed here re-enforced this East-West split. A third large scale group is made up of samples collected from the Laptev and Greenland seas. The degree of genetic differentiation between and within these large scale groups will be discussed in the context of environmental variables which may serve to shape the population structure observed.

Fishes in the U.S. Beaufort Sea

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The US and Canada share the Beaufort Sea continental shelf and slope ecosystem. Minimal historical data exist for habitat and ecology of the transboundary fish species that range across the US and Canada border on the Beaufort Sea shelf. Marine fish surveys have been conducted occasionally from Barrow to the Alaska – Canada border. As offshore oil and gas exploration interest expands, more information about the sparsely documented fish species inhabiting the area is required. In 2011, University of Alaska Fairbanks and Bureau of Ocean Energy Management researchers conducted fish surveys in the Alaskan Beaufort Sea from Point Barrow (156°W) to Camden Bay (146°W). Approximately 13,000 fish from 32 species, representing 11 families were captured. In September 2012, UAF researchers collected fish in a limited portion of that area, 150-151°W. Preliminary results from the 2012 field season will be presented along with fish distributions from 2011 data. The plan had been to trawl for marine demersal fishes from Camden Bay to the Canadian border, approximately 141°W, while scientists from Canada's Department of Fisheries and Oceans sampled the Canadian Beaufort Sea from the Canadian border to approximately 130°W. A continuing whaling season prevented sampling around Kaktovik. Additional cooperative research cruises are planned for 2013 and 2014. This joint research, which covers the entire Alaskan Beaufort and part of the Canadian Beaufort over multiple years, will provide information about abundance, distribution, habitat, and interannual variability of both fish in open water season.

Impact of Arctic Climate Warming on Juvenile Salmon Abundance and Condition in the Northeastern Bering and Chukchi Seas

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The Arctic is warming at an unprecedented rate. Associated with rising temperatures are decreases in thickness and coverage of summer snow and ice. These changes in temperature and summer sea-ice extent are resulting in a notable shift in the northeastern Bering Sea and Chukchi Sea (NEBS/CS) systems from Arctic to more subarctic conditions. Consequently, increases in the abundance of juvenile chum (*Oncorhynchus keta*) and pink salmon (*O. gorbuscha*) have been observed. To date, there is little information on salmon distribution in the Arctic. This project will focus on the ability of the NEBS/CS regions to support juvenile pink and chum salmon growth by measuring insulin growth factor-I (IGF-I) levels, energy content, and analyzing diet. IGF-I is a growth hormone that stimulates muscle and cartilage growth and is an accurate measure of relative growth rate in many teleost species. In addition to data collected during the scheduled 2012 and 2013 surveys, this project will use diet and energetic data collected by the Bering-Aleutian Salmon International Surveys (BASIS) to allow for a comparison to be made between warm (2001-2005) and cold (2006-Present) regimes. With increasing utilization of the Arctic for summer feeding grounds by juvenile salmon, it is important to describe Arctic regions to determine whether these habitats are conducive to early developmental growth and condition of salmon species. Understanding the relationships between diet, growth, and temperature are necessary and will benefit fisheries managing salmon returns and assist in adaptation of fishery management to increasing climate variability.

Arctic - Seabirds

Biogeochemical indicators of change in high- and low-Arctic marine bird communities: Comparative isotopic (13C, 15N, and 34S) studies in Alaska and Greenland

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Avian communities of marine and terrestrial Arctic environments represent a broad spectrum of trophic levels, from herbivores (eg. geese *Chen spp.),* planktivores (eg. auklets *Aethia spp*.), nearshore and offshore fish (eg. cormorants *Phalacrocorax spp*, puffins *Fratercula spp*.), and even other bird species (eg. gulls *Larus spp*., falcons *Peregrinus spp*.). This diversity of trophic interconnections is an integral factor in the dynamics of Arctic ecosystem ecology, and they are key indicators for the strength and trajectories of change. Since 2009, we have been studying the foodweb ecology using stable isotopes (δ13C, δ15N, δ34S) of contemporaneous coastal and marine bird communities in High Arctic (Northwest Greenland) and Low Arctic (western Aleutian Islands, AK). Although geographically distant, these communities comprise similar taxonomic and ecological congeners, including several species common to both (eg. Common Eider, Black-legged Kittiwake, Northern Fulmar). Generally, High Arctic species have tissues that are more enriched in δ15N compared to their Low Arctic counterparts, but δ13C values are similar in both regions. We hypothesize that these patterns are probably related to isotopic variations in food rather than trophic level differentiation. Both Low- and High-Arctic bird communities show decadal-period shifts in stable isotope profiles, based on prior published results and previously collected specimens.

Monitoring murres and kittiwakes at Cape Lisburne, Alaska, 1976-2012

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During the breeding season Cape Lisburne, in the eastern Chukchi Sea, supports an estimated 400,000-500,000 common and thick-billed murres (*Uria aalge* and *U. lomvia*; about 75% thick-billed) and 20,000-30,000 black-legged kittiwakes (*Rissa tridactyla*) on about 7 km of 15- to 200-m-high sedimentary limestone and shale sea-cliffs. Smaller numbers of pelagic cormorants (*Phalacrocorax pelagicus*), black guillemots (*Cepphus grylle*), parakeet auklets (*Aethia psittacula*), horned and tufted puffins (*Fratercula corniculata* and *F. cirrhata*), and glaucous gulls (*Larus hyperboreus*) also breed at this site. This large and impressive seabird colony is one of the Alaska Maritime National Wildlife Refuge's nine annual seabird monitoring sites and the northernmost breeding location for most of these species in Alaska (glaucous gulls and black guillemots are the primary exceptions). Murre and kittiwake populations have been monitored at Cape Lisburne since 1976. Based on boat- and land-based counts (1976-2012 and 1987-2011 respectively), numbers of murres and kittiwakes have increased since surveys began. Average kittiwake productivity declined throughout the study period. These changes may be related to the effects of changing environmental conditions (e.g., an increase in summer sea-surface temperature; earlier breakup, retreat, and dissipation of ice cover) on the availability of prey. During 2012 we tested the use of time-lapse cameras for monitoring murre and kittiwake breeding performance and timing. Challenges of time-lapse camera work at this location included upward-looking views, frequent rain, and curious brown bears. The cameras successfully recorded images of murre breeding postures and nesting kittiwakes every 15 minutes for four weeks. This technology added plots and observation-days to those we obtained by observing the nest sites through binoculars.

Arctic - Seabirds

New Neighbors: Shifts in the marine-bird community of the Chukchi Sea over the past 35 years

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Summer ice cover in the Arctic Ocean in 2012 has the lowest minimum extent on record. These habitat changes will have repercussions on the trophic structure in this environment, and there are indications that changes have already taken place in the marine-bird community. We compared boat-based survey data collected in the Chukchi Sea during the Outer Continental Shelf Environmental Assessment Program in the late 1970s and early 1980s with surveys conducted during the last 5 years following a comparable protocol to explore how changes in the physical and biological oceanography of the Chukchi Sea may be affecting the marine-bird community. Historical data indicate that the community was composed primarily of piscivorous Black-legged Kittiwakes (*Rissa tridactyla*) and murres (*Uria spp*.). In contrast, data collected during 2007–2012 suggest that the marine-bird community in the Chukchi Sea is now composed primarily of planktivorous seabirds such as Crested Auklets (*Aethia cristatella*) and Short-tailed Shearwaters (*Puffinus tenuirostris*). In addition to an apparent shift in the composition of previously recorded species, new species have been added to the community. Additions to the avifauna of this region include single sightings of Northern Gannet (*Morus bassanus*) in 2010 and Short-tailed Albatross (*Phoebastria albatrus*) in 2012, plus substantial numbers of Ancient Murrelets (*Synthliboramphus antiquus*), which have been recorded north of Bering Strait only since 2007. We propose that the changes in the marine-bird community reflect an increase in the abundance of zooplankton prey in the region.

Identifying important pelagic areas in the Pacific Arctic:
Seasonal and spatial patterns in marine bird and mammal distribution

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The prospect of rapid climate change and increases in human activities in the Pacific Arctic will require improved understanding of the relationships among oceanographic conditions, lower trophic species, and higher trophic species. Our project, as part of the multidisciplinary Synthesis of Arctic Research (SOAR), will describe the broad scale pelagic distribution of marine birds and marine mammals in the North Bering Sea, Chukchi Sea and Alaskan Beaufort Sea. We will examine seasonal patterns in distribution, especially relative to ice cover, and identify areas with high diversity and high relative abundance, which can be used to focus future efforts on mechanisms affecting upper trophic levels. We will integrate existing data from 2006-2011, including line transect aerial surveys for marine mammals (~139,000 km surveyed) and strip transect shipboard surveys for seabirds (~ 25,000 km surveyed). We will: (1) Quantify spatial and seasonal patterns in marine mammal and seabird community structure in the Pacific Arctic in spring (March-May), summer (June-August) and fall (September-November). (2) Identify areas where marine mammal and bird density or diversity do and do not overlap. (3) Suggest life history and physical mechanisms that contribute to the formation of the identified patterns. This is a collaborative effort between the National Marine Fisheries Service and U.S. Fish and Wildlife Service, with funding and support from the Bureau of Ocean Energy Management. We anticipate incorporating additional information from industry surveys, community observations, and other federal studies. We present some preliminary results, with expected project completion in late 2013.

Arctic - Seabirds

Short-term responses of seabirds to environmental stress: are differences predicted by life history theory?

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Life history theory predicts how species trade off the allocation of limited resources into self-maintenance versus reproduction. The continuum of different strategies contrasts 'slow' and 'fast' living species, with 'slow' species allocating resources more prudently towards reproduction to ensure longer survival and vice versa. While this concept has been shown to explain responses of different species to environmental changes, it remains to be tested if it applies to different populations of a single species. Atlantic and Pacific populations of the black-legged kittiwake appear to differ in their life history strategies. Pacific kittiwakes are 'slow' living (low reproductive success and high adult survival) while the opposite patterns are typical for Atlantic kittiwakes. To test the hypothesis that kittiwake reproductive responses differ when facing stressful periods (i.e. 'slow' living kittiwakes should show higher reduction of reproductive effort compared to 'fast' living kittiwakes), we conducted an experimental study in both regions. We implanted kittiwakes with stress hormones during the chick-rearing period and measured adult nest attendance, and the effects on survival of the chicks. Our results indicate that experimentally stressed Pacific kittiwakes allocated less time attending their young, which lead to lower reproductive success. In contrast to this, experimentally stressed Atlantic kittiwakes did not reduce their investment in chicks, and their reproductive success was not affected. We conclude that the short-term responses to stress followed the differences in life history strategies, since Pacific kittiwakes allocated more prudently into reproduction, and were more likely to experience higher survival compared to their Atlantic conspecifics. Our finding contributes to the understanding of seabird responses to environmental challenges, and has important implications for predictions of population responses to ongoing climate change.

Arctic - Mammals

Bowhead whales and airgun pulses: detecting threshold levels of behavioral reaction

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To properly assess the effects of oil and gas exploration on populations of Arctic marine mammals such as bowhead whales, it is necessary to have knowledge on the various behavioral reactions that an individual can exhibit in response to an activity or the sound produced by that activity. When subjected to low levels of sound from airgun pulses, bowhead whales increase their calling rates over those recorded in the absence of seismic operations. Furthermore, the whales cease calling when relatively near (<40 km) an airgun array, where received levels (RLs) are higher. The goal of this study is to estimate the RL thresholds for these two changes in calling behavior. About 975,000 localized bowhead calls and ~2 million airgun pulses were collected during late summer of 2007–2010 by a total of 40 Directional Autonomous Seafloor Acoustic Recorders (DASARs) in the Beaufort Sea. A subset of ~50,000 calls, whose probability of detection was independent of background levels, were included in the analyses. These calls were all within 2 km of one of the DASARs. For each 10-min period of data collected at each recorder, each year, the cumulative sound exposure level (CSEL) from airgun pulses was calculated and paired with the number of calls concurrently localized within 2 km of each DASAR. Poisson regression was then used to estimate the two thresholds of airgun sound exposure received at the whales: (1) the level at which bowhead calling rates have increased to their maximum and (2) the level at which calling rates have begun to decrease. These two CSEL thresholds were found to be near 92 dB and 126 dB re 1 μPa2 s, respectively (95% confidence intervals = 90–103 dB and 120–129 dB re 1 μPa2 s, respectively). If we assume an airgun array firing every 10 sec and producing constant pulse amplitudes, the upper threshold of 126 dB corresponds to a received single pulse SEL at the whale of ~109 dB re 1 μPa2 s. [Work supported by Shell Exploration and Production Company.]

Arctic - Mammals

Winter site fidelity of bearded seals in the Bering Sea

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Six bearded seals (*Erignathus barbatus*) were tagged with small satellite-tracking transmitters attached to their hind-flippers in Kotzebue Sound, Alaska, during late June or early July of 2009 (three males) and 2011 (two females and one male). After spending the months of August – December in the Chukchi or Beaufort seas, the three individuals tagged in 2009 migrated south to the Bering Sea where they spent the months of January – April, 2010. Their wintering areas were typically restricted to a radius of about 40 km. Two individuals wintered near each other in the upper reaches of Norton Sound, while the other wintered near the sea ice edge in the vicinity of St. Matthew Island. During the winter of 2011, all three individuals again used the same spaces they had occupied in 2010. In the winter of 2012, the pattern was repeated, and at the same time, the three seals tagged in 2011 took up their (unique) wintering locations in the Bering Sea. We predict that in the winter of 2013, the latter three seals will return to the same areas used in 2012, confirming a pattern that suggests strong philopatry in this species. The two sub-adults tagged in 2009 are now, after three years have elapsed, likely to be full adults; Bering Sea bearded seal males, at least, exhibit strong winter site fidelity, apparently establishing their preferred sites even as sub-adults. This is the first direct confirmation of site fidelity in bearded seals, and it is consistent with inference drawn from acoustic recordings in successive years and with genetic studies that have found population structure in this species. Strong fidelity to wintering sites may limit bearded seals' capacity to adapt to shifting ice distributions in a warming Arctic climate.

Gray Whale Calf Occurrence in the Alaskan Arctic, Summer and Fall 2012

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Marine mammal surveys were conducted in the northeastern Chukchi and western Beaufort seas (68-72°N and 140-169°W) from July to late October, 2012, as part of the Aerial Surveys of Arctic Marine Mammals project conducted by the National Marine Mammal Laboratory and funded by the Bureau of Ocean Energy Management. Additional surveys, sponsored by the Alaska Beluga Whale Committee, were flown in early July up to 45 nm offshore in the northeastern Chukchi Sea to target belugas. Surveys were conducted in the larger study area from 1982 to 1991, and recommenced in 2008. Gray whale calves were sighted with far greater frequency in the Chukchi Sea in 2012; total numbers are far higher than gray whale calf sightings recorded in previous years, which were highest in the years 1982, 1985, 2009, and 2011. Gray whale calves in 2012 were particularly abundant in the month of July (n=57); few calves were seen in August, September or October, similar to previous years. Distribution of calves was also similar to previous years: primarily nearshore along the Alaskan coast from Point Lay to just east of Barrow, with particularly high numbers near Point Franklin and in ice-free, shallow water (<50 m). This area is an important foraging ground for gray whales; feeding was the dominant behavior documented in this area throughout the survey years. It is possible that these shallow waters provide protection from predators; killer whales were sighted in multiple locations in the Chukchi Sea in 2012. In gray whale calf counts conducted along the California coast by the Southwest Fisheries Science Center during the annual northern migration, calf counts were also high in 2012 when compared to previous years' counts. It is possible that conditions were favorable for foraging in 2011 and many females were able to accumulate sufficient energy reserves to reproduce in 2012. Another possibility is that other habitats where gray whale cow-calf pairs have been documented in the past, such as just west of Point Hope and along the Chukotka Peninsula, may not have been as favorable to cow-calf pairs in 2012.

Fish species identified in bearded seal diet using stomach contents and fecal DNA

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The diet of marine mammals can be assessed using various techniques, but each has limitations. Therefore a combination of these techniques will likely yield the best dietary information. In this study we use the combination of stomach contents and prey DNA molecules extracted from feces to identify fish consumed by bearded seals (*Erignathus barbatus*). When using stomach contents alone, complete digestion of some prey and retention of others varies, which can yield a biased and incomplete interpretation of prey composition. Soft bodied prey and fish with small otoliths can go undetected, whereas other species may be overrepresented relative to their true proportion in the diet. Additionally, otoliths or other diagnostic parts may not be taxonomically identifiable to the species level. For example, otoliths from sculpin (*Myoxocephalus spp., Gymnocanthus spp*.) and snailfish (*Liparis spp*.) are often found in the stomachs of bearded seals collected in Alaska, but it is unknown what species they represent. Although degraded by digestion, DNA molecules present in the gut and feces can be isolated and processed to identify prey species. This gene-based approach can identify important prey items that were previously undetected or unidentifiable using hard parts from stomach contents. This study identifies fish species in the diet of seven bearded seals using a combination of stomach contents and fecal DNA analyses.

Recent Sea Ice Minima Effect on Trophic Structure in the Chukchi Sea

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Climate change and sea ice reduction in the Arctic may lead to modifications in productivity and food-web structure affecting the foraging of higher trophic predators. Record sea ice minima in the Arctic have been reported since 2007. We investigated stable nitrogen and carbon isotope ratios of fish prey, five fish species, and claws of two ice seal species to describe interannual changes in trophic structure in the Chukchi Sea from 2007 through 2009. Pelagic crustaceans, prominent fish prey taxa, had significantly lower δ15N values in 2007 compared to 2008 and 2009, possibly a result of a high primary productivity period in 2007. Nutrients were not limiting during July/August 2007 allowing for phytoplankton to use more of the lighter/preferred nitrogen isotope later in the season. Lower δ15N values at the base of the food chain in 2007 likely propagated up to fish and pinniped predators. Stable isotopes of fish tissue illustrate average diet history from the previous year. Stout eelblenny (*Anisarchus medius*) and Bering flounder (*Hippoglossoides robustus*) had significantly lower δ15N values in 2008, reflecting prey consumption in 2007. Seasonal keratin layers deposited in seal claws can document trophic history up to about 10 years. During 2007, ringed seal (*Pusa hispida*) and bearded seal (*Erignathus barbatus*) claws had lower δ15N values compared to prior years. Alternatively, lower δ15N values for higher trophic predators may be the result of these consumers taking advantage of an increased zooplankton biomass during 2007. Changes in productivity and/or prey availability appear to have impacted the trophic structure in the Arctic during 2007, with stable carbon isotope data supporting the latter scenario.

Aerial sightings of Pacific walruses (*Odobenus rosmarus divergens*) in the Alaskan Arctic, summer and fall 2012, with a comparison to sightings from 2009-2011

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Marine mammal aerial surveys were conducted in the Alaskan Arctic from summer through fall 2012, as part of the ongoing Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by the Bureau of Ocean Energy Management. Additional aerial surveys, funded by the Alaska Beluga Whale Committee, were conducted in July to assess the eastern Chukchi Sea stock of belugas. The primary study area encompassed the western Beaufort and northeastern Chukchi seas (68°N-72°N, 140°W-169°W), extending from the coast to a maximum of approximately 315 km offshore. A secondary survey area in the Chukchi Sea, located north of the primary study area (72°N-73°N, 160°W-163°W), was also flown. In 2012, Pacific walruses were primarily encountered in the northeastern Chukchi Sea, with few sightings in the western Beaufort Sea. From early to mid-summer, walruses were distributed nearshore between Point Barrow and Cape Lisburne, and offshore between 153°W-167°W. By late summer and early fall, walruses were mainly in the northern extent of the study area in Barrow Canyon, between Icy Cape and Point Barrow, and in the vicinity of Hanna Shoal (72°N, 162°W). Walruses were either in the water or hauled out on sea ice and, as of 26 September, no walruses had been observed hauled out on land along the northern Alaskan coastline. Pacific walruses were observed in the northeastern Chukchi Sea in the summer and fall of 2009-2011, and large walrus haulouts on land were encountered by either mid-August (2011) or early September (2009, 2010). Sea ice was absent in, and north of, the study area by late summer in 2009-2011, likely resulting in walrus movement closer to shore and, consequently, in the formation of large walrus aggregations on land. In 2012, despite sea ice receding to a record minimum extent, diffuse ice floes persisted in the northern part of the study area near Hanna Shoal. The persistence of sea ice remnants near Hanna Shoal throughout the summer and fall in 2012 likely provided enough at-sea haulout space, making land haulouts unnecessary in August and most of September.

Arctic - Mammals

It's Not Just About Bowhead Whales – Collaborations between ASAMM and other Research

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The Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by the Bureau of Ocean Energy Management (BOEM), is the successor to the Bowhead Whale Aerial Survey Project (BWASP), which started in the late 1970s and has continued uninterrupted since. During this time period, the Arctic has undergone profound changes, and ASAMM has also evolved in its purpose and products. The primary focus of BWASP was to document the migration of bowhead whales (*Balaena mysticetus*) across the western Beaufort Sea, although data on all marine mammals were collected. ASAMM continues to document marine mammal distribution, behavior and relative density to meet its stated objectives, but also fosters collaborations with various researchers from local, state and federal agencies. The large ASAMM study area, spanning the entire Alaskan North Slope from 68°N to 72°N and 140°W to 169°W, allows ASAMM to collect visual data on several physical and biological factors that would otherwise not be available, and to share this information in a timely manner. Recent collaborations include, but are not limited to: 1) providing real-time walrus ice haulout information to U.S. Geological Survey (USGS) personnel to assist with satellite tagging efforts; 2) providing walrus and polar bear sighting data to USGS, U.S. Fish and Wildlife Service (USFWS) and Alaska Department of Fish and Game (ADFG); 3) cooperation with the Alaska Beluga Whale Committee (ABWC) and North Slope Borough Department of Wildlife Management (NSB DWM) on aerial surveys focused on eastern Chukchi Sea belugas; 4) providing biweekly bowhead whale sighting data to the U.S. Coast Guard (USCG) in support of Arctic Shield 2012; 5) providing Level A stranding reports for marine mammal carcasses to NSB DWM, USFWS, and the National Marine Fisheries Service (NMFS); 6) locating wayward meteorological-oceanographic buoys for eventual retrieval by owners; and 7) sending sea ice images to the USCG, NOAA research vessels and the National Weather Service Sea Ice Desk to ground-truth ice images available from satellites. These collaborations, in addition to near real-time posting of daily flight reports and allowing public access to historical data, make the ASAMM project valuable in a broader scientific context.

Belugas (*Delphinapterus leucas*) in the Alaskan Arctic, Summer and Fall 2012, with Comparisons to 2007-2011

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Aerial surveys for marine mammals were conducted in the northeastern Chukchi Sea and western Beaufort Sea from early July through late October 2012, under the auspices of the ongoing Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by the Bureau of Ocean Energy Management (BOEM). Additionally, effort specifically designed to survey the Eastern Chukchi Sea beluga stock was flown from 30 June to 12 July, sponsored by the Alaska Beluga Whale Committee (ABWC). The combined study area encompassed approximately 230,000 km2, extending from 140°W to 169°W and 68°N to 72°N. Twin Turbine Aero Commander aircraft with 5.5 hour flight endurance, outfitted with bubble windows for downward visibility, were used for all surveys. Line-transect surveys were flown every day, weather and logistics permitting. Survey effort in 2012 was similar to that flown in 2011, with >50,000 km flown (not including deadhead or unusable effort), including ~40,000 km on transect. Sea ice remained in parts of the study area in summer longer than in recent years (2009-2011), but receded to zero percent in much of the study area (particularly the western Beaufort Sea) by early fall. In late June to mid-July, >8,600 km were flown on coastal and offshore transects in the northeastern Chukchi Sea. Despite this effort, very few belugas were seen offshore. Specifically, groups ranging in size from 1 to 300 belugas (representing >90% of beluga sightings) were observed within a few kilometers of shore while only two sightings of single belugas (representing <10% of beluga sightings) were observed offshore. Large groups (n=150-300) of belugas were observed feeding near entrances to Kasegaluk Lagoon on four days in late June and early July. Belugas remained largely absent in offshore areas of the northeastern Chukchi through August and September. In the western Beaufort Sea, belugas were seen from July through October 2012, with the lowest numbers observed in early September. Distribution and areas of concentration (belugas per km per depth zone) in the western Beaufort Sea heavily favored the continental slope and Barrow Canyon. Beluga distribution in 2012 remained similar to that observed from 2007-2011, although some prominent differences do exist.

Results from village-based walrus studies in Alaska, 2012

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Pacific walruses 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 summer walrus habitat in the Chukchi Sea and may be changing summer distributions and haulout behavior, requiring that walruses haul out on land instead of ice. The purpose of this project is to work with subsistence walrus hunters to conduct observations at terrestrial haulouts accessible from coastal communities, deploy satellite-linked tags to monitor movements and feeding behavior, and to document local knowledge regarding terrestrial walrus haulouts. Local knowledge collected in Point Lay and Wainwright described historical occurrences of terrestrial walrus haulouts and detailed the steps taken by communities to minimize disturbances. In February, we co-sponsored a workshop on coastal walrus haulouts and provided travel to Barrow for several elders and walrus hunters to discuss walrus haulout issues with each other and management agencies. In May, we worked with hunters to deploy satellite tags on walruses near Little Diomede Island, but were unsuccessful due to unfavorable sea ice and weather conditions. During August and September, local hunters were prepared to monitor the haulouts from blinds using spotting scopes and they assisted in the construction of camera towers to potentially monitor walrus behavior near the previous haulout site. Sea ice, however, persisted in the northern Chukchi Sea and walruses did not haul out in large numbers along the Alaskan coast as they had in recent years (20,000–25,000 walruses in September 2011). Also in August, residents of Little Diomede Island began to monitor terrestrial haulouts and causes of disturbance in the area.

Mapping landscape features suitable for polar bear maternal dens in coastal regions of the National Petroleum Reserve – Alaska using an IfSAR digital terrain model

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Polar bears (*Ursus maritimus*) give birth to their young during winter in dens of snow and ice. The Arctic Coastal Plain (ACP) in northern Alaska provides denning habitat for polar bears. Because polar bears are dependent on and live most of their life on Arctic sea ice, the ACP is a critical link between terrestrial and marine environments. The ACP also has high potential for recoverable hydrocarbons, therefore efforts must be made to assure winter-time oil and gas activities do not disrupt denning and threaten survival of cubs. To do so, managers require knowledge of the distribution of the landscape features in which pregnant polar bears are most likely to dig maternal dens. We present a map of snow-catching landscape features suitable for polar bear denning within the National Petroleum Reserve-Alaska (NPR-A). We used a fine-grain digital elevation model, derived from Interferometric Synthetic Aperture Radar (IfSAR), to generate a map of putative denning habitat within NPR-A, and then tested whether that map consistently identified polar bear denning habitat on the landscape. Our map of estimated denning habitat identified 82 % of actual den habitat within NPR-A. The map was conservative because 18 % of mapped habitat was inadequate for denning. Denning habitat was widely dispersed and comprised 0.1 % (19.7 km2) of the total area of IfSAR coverage in the NPR-A. Den habitat mapping with IfSAR data was as effective as mapping with photogrammetric methods used for other regions of the ACP. While photogrammetric methods are labor-intensive and results dependent on potentially subjective interpretation, mapping with IfSAR depends only on objective criteria, has greater flexibility, and requires less manual labor. IfSAR data can be interrogated quickly and consistently with standard GIS tools and the detection sensitivity can be adjusted to the desired level of omission and precision. Ease of use, greater objectivity, and equivalent performance to manual cartographic methods suggests that using IfSAR data to identify polar bear maternal denning habitats is a useful management tool in the NPR-A and wherever such data may be available.

Arctic - Mammals

Summer in the Western Beaufort Sea: Results from Aerial Surveys of Arctic Marine Mammals, July and August, 2012

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The lengthened open water season and reduced sea ice coverage in the Arctic foretell increased human activities in this region, including shipping, fishing, recreation, and oil and gas exploration, development, and production. In order to minimize and mitigate the effects of anthropogenic activities on arctic marine mammals, information on marine mammal ecology is needed for all seasons in which activities could occur. Aerial surveys have proven effective for studying the distribution and behavior, and inferring the density, of arctic marine mammals within large study areas. Since 1987, broad-scale aerial survey coverage in the western Beaufort Sea has been mainly limited to the months of September and October. Between 19 July and late October, 2012, the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by BOEM and conducted by NOAA, conducted line-transect surveys for marine mammals over a vast (~107,600 km2) study area in the western Beaufort Sea (140°W to 157°W, from the coast to 72°N). During the summer (19 July through 29 August), ASAMM flew 25 surveys in this region, including over 14,000 km on transect, with total summer flight effort amounting to over 28,500 km. Bowhead whales were found on 13 days, distributed primarily along the outer continental shelf, in 58 sightings totaling 115 whales, including 11 calves. Belugas were found on 23 days, distributed primarily over the continental slope, in 385 sightings totaling 2220 individuals. Gray whales (19 sightings, 45 individuals, including 2 calves) were sighted on two days, near Barrow Canyon. Walruses (28 sightings, 923 individuals) were sighted on four days, near Barrow Canyon and over the continental slope in the western half of the region. Polar bears (11 sightings, 28 individuals, including 4 cubs or yearlings) were sighted on four days: 20 bears were found on Cross Island, 4 were located on barrier islands east of Kaktovik, and 4 were sighted swimming between 10 to 85 km offshore. One sighting of 13 killer whales (including 2 calves) was found near Barrow. These data help fill an important information gap into marine mammal ecology during the summer in the western Beaufort Sea.

Spatio-temporal distribution of male bearded seals in the Chukchi Sea using underwater vocalizations

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The Chukchi Sea Environmental Science Project, sponsored by Statoil, ConocoPhillips, and Shell, includes passive acoustic monitoring that has operated almost continuously since summer 2006. Bearded seal (*Erignathus barbatus*) is a highly vocal ice seal that is widely distributed in the high north. Little is known about bearded seal abundance in the Chukchi Sea due to the relative inaccessibility of the Arctic. By using autonomous long-term acoustic recordings, researchers have been able to investigate the acoustic behavior and seasonal occurrence of marine mammals in areas, and in periods, where ship-based or on ice studies were not previously possible. In this study, underwater vocalizations of male bearded seals that occurred between July 2007 and October 2009 were analyzed. Bearded seals were identified by their trills, ascents and moans. To determine the seasonal variation in the occurrence of male bearded seal vocalizations in a year, call counts were determined by analyzing 20 minute recordings between 2:00 and 6:00 a.m., from every third day. Bearded seal acoustic detections increased progressively from August to March, peaked between April and June, but were essentially absent in July. Outside of the mating period (April–June), the occurrences of vocalizations varied on a diel cycle, being higher during periods of darkness. To determine the influence of a diel cycle, the durations of vocalizations and the proportion of each vocal type were analyzed using 10 minute recordings on a 17-20% duty cycle every tenth day throughout the year. Results are currently under review and will be presented.

Spatiotemporal distribution of Alaskan beluga (*Delphinapterus leucas*) populations based on acoustic monitoring

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Beluga whales (*Delphinapterus leucas*) are highly vocal animals which make them ideal candidates for passive acoustic monitoring. In Alaska, two subpopulations migrate annually from their predictable summering grounds in the eastern Chukchi and eastern Beaufort Seas, to overwinter in the Bering Sea. Additional information is required on the timing and migration routes in spring and autumn to assist in following these subpopulations as they transit between the two regions. Preliminary results are presented on the temporal distribution of Alaskan beluga based on acoustic detections (September 2010 to June 2011) from passive acoustic recorders located in the eastern Chukchi, western Beaufort, and Bering Seas. Due to the highly vocal nature of beluga and their migratory movement patterns within the region, multiple temporal peaks in vocal activity are evident. Within each temporal peak in vocal activity we will investigate the common call types to assist in differentiating migratory streams, and potentially identify each subpopulation as they transit through each region and the wider Arctic. [Work supported by the National Research Council and Bureau of Ocean Energy Management].

Quantifying line entanglement and ship strike rates for Western Arctic bowhead whales

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Biologists have conducted postmortem examinations on bowhead whales harvested by Alaskan Eskimos for over 30 years. Scar types have been described for this entire period and systematically recorded the 1990s. Scars provide evidence of line entanglement, ship strikes, killer whale, hunting and other past injuries. We attribute most entanglement injuries to fishing/crabbing gear. Preliminary examination of data for the period since 1990 for whales landed at Barrow and Kaktovik was conducted. Based on these data, we suggest ~10% as a reasonable preliminary estimate of the percentage of harvested bowhead whales that have evidence of past line entanglement based on scarring. Similarly about 1-2% exhibit ship strike injuries. All scar types were more frequent on adult whales (>13 m body length). At least five bowheads since 1990 have been found dead entangled in line gear. Entanglement and ship injury rates appear low compared with large whale populations elsewhere but management measures need to be considered now to minimize the risks of expanding shipping, offshore oil and gas, and commercial fishing in the Arctic.

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Hunter based observations of bowhead and gray whales near Barrow, Alaska

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The North Slope Borough has been conducting hunter-led small boat surveys near Barrow, Alaska for the past five summers as part of the BOEM-funded Bowhead Whale Feeding Ecology Study (BOWFEST). Information from this study will be used by BOEM for pre- and post-lease analysis and documentation under the National Environmental Policy Act (NEPA) for Beaufort Sea and Chukchi Sea Lease Sales. The study will also add to the general body of knowledge regarding the feeding ecology of large cetaceans. As a broad pattern, bowhead whales of the Bering-Chukchi-Beaufort Seas Stock (BCBS) typically winter in the Bering Sea and migrate to the Canadian Beaufort Sea in summer to feed, returning again to the Chukchi and Bering Seas in autumn/winter. Gray whales generally migrate from far more southern latitudes to the Bering and Chukchi Seas to feed in summer. Feeding and relative abundance patterns of these two species were studied using local hunters to record positions and behaviors of whales in the Barrow region during summer and early autumn. In some years bowhead whales occur near Barrow, Alaska in low numbers with abundance varying considerably by year. Gray whales consistently occur and feed near Barrow, however abundance varies but much less so than bowheads. Bowheads and gray whales show spatial segregation within the study area with gray whales aggregating west of 156 W longitude and bowheads mainly occurring east of that line. In 2008, 2009 and 2012 bowheads were more frequent near Barrow in July to early September, than in 2010 and 2011. Very few bowheads were seen in August and September in 2011 despite the highest sighting effort of any survey year. We speculate on why this may have occurred. Locally operated boat surveys are an effective, relatively low-cost means to support various scientific studies including whale distribution and abundance surveys. The strengths and limitations of this research approach are discussed.

A Comparison of Altimeters Used in Aerial Photogrammetry

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Body length is a fundamental measurement in wildlife studies and is needed to assess population size structure, growth rates, maturity status, and allometric relationships. While morphological measurements are relatively easy to obtain for small terrestrial animals, these measurements are much more difficult to collect from large, free-ranging marine mammals that move within a three-dimensional environment. Photogrammetric methods, using an aerial platform, provide a practical method to obtain length measurements. A critical component to documenting lengths through photogrammetry is to accurately establish the aircraft's altitude, or the distance between the camera and target. While radar altimeters have provided a gold star standard in obtaining accurate and reliable altitude measurements for photogrammetric work in the past, alternative and less expensive technologies with advertised greater accuracies, have yet to be tested and compared to these measurements. In this study, we compare measurements from radar, laser, and GPS (satellite and barometric) altimeters relative to the 'true' altitude calculated from precisely measured calibration targets. As part of the Bowhead Whale Feeding Ecology study (BOWFEST; funded BOEM), we flew over land-based calibration targets at 30.5 m (100 ft) increments from 152 to 457 m (500 to 1500 ft) at a speed of 185 km/h (100 kt) to determine the relationship between altitudes recorded by various technologies and those calculated from known distances. We used a Canon EOS-1DS Mark III digital camera with motion compensation mounted over an open hole in the floor of the aircraft to photograph the target. In total, we obtained 26, 19, and 16 images of the target in 2009, 2010, and 2011, respectively. All measurements of the calibration target were calculated directly from the original digital photograph and compared to known measurements in order to determine the 'true' altitude of the aircraft. Using regression equations, we calculated variation in performance of the four altimeters. Overall, the radar altimeter was the most accurate, followed by the barometric altimeter. The satellite and laser derived altitudes were the least accurate. In projects when an open port is not available or when budgets are limited, the GPS barometric altimeter may provide adequate altitudes for aerial photogrammetry.

Short- and long-term distribution of marine mammals in the Chukchi Sea

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With the western Arctic climate rapidly changing, risks to marine mammals are rising. The extended open water season caused by the severe retreat in sea ice allows not only for a longer oil and gas exploration period each year, but a greater range expansion among marine mammals. In order to better understand these risks, an in-depth year-round knowledge of marine mammal distribution within the Chukchi is needed. The CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton) study began in 2010 and includes four components; oceanography, passive acoustics, zooplankton, and climate modeling aimed at determining marine mammal presence in the Chukchi Sea and their response to environmental change. During the 2012 field season (Aug 15th – 31st) 749 miles of trackline were visually observed and 101 sonobuoys were deployed. Of the 101 buoys deployed, 91 transmitted successfully. The visual observers had 36 sightings of 49 cetaceans consisting of six species (only one whale sighted was not positively identified) and 131 sightings of 423 pinnipeds, of which 43% were walrus sightings. Additionally one polar bear was sighted. The most common species detected acoustically were humpback and fin whales, heard on 11% and 8% of the buoys, respectively. Notably no seismic airguns were detected. In addition to the real time monitoring of the area, long term (year-long) AURAL (Autonomous Underwater Recorder for Acoustic Listening, Multi-Électronique, Rimouski, QC, Canada) recorders were deployed starting in August 2010. The recorders were deployed in clusters of five at three locations (30, 60, and 100 miles) off Icy Cape. A single recorder from each cluster deployed from 2010 to 2011 has been analyzed for the presence of bearded seals, beluga, fin, and bowhead whales.

Polar bear use of a persistent food subsidy: insights from non-invasive genetic sampling

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Remains of bowhead whales (*Balaena mysticetus*) harvested by Iñupiat whalers are placed in bone piles along the North Slope of Alaska and have become persistent and reliable sources of food for polar bears (Ursus maritimus). The influence of these bone piles on the health and status of the polar bear populations in this region is unknown. We developed and implemented barbed-wire hair snaring, applied for the first time for polar bears, to obtain genetic identities from bears using the bone pile at Point Barrow in the winter of 2010 – 2011. Eighty-two percent of our samples produced enough genetic material to provide individual and sex identification. Our snare was successful at capturing hair from dependent young. We identified 97 bears from 200 samples, 38% of which had been previously physically captured in the southern Beaufort Sea polar bear population. We estimated that 228 polar bears used the bone pile over the course of the three-month study, representing approximately 15% of the southern Beaufort Sea polar bear population. We found that polar bears of all age and sex classes simultaneously used the bone pile, although subadults were largely absent from the known-age sample. More males than females used the bone pile, and males predominated in February, likely because 1/3 of adult females would be denning during this period. On average, polar bears spent about 10 days at the bone pile; the weekly fidelity probabilities were 63% for females and 45% for males. We found some evidence of matrilineal fidelity to the bone pile, but animals did not significantly differ genetically from the population as a whole. Further, the patterns of relatedness did not differ between the population and the group of polar bears at the bone pile. This methodology holds promise as a non-invasive method for polar bear research and management.

Preliminary analyses of stable isotopes, hormones, and minerals of baleen from bowhead whales (*Balaena mysticetus*)

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Bowhead whales inhabit an ecosystem undergoing dramatic changes in sea ice and temperature and are of great importance to indigenous people of the North Slope of Alaska. Information on reproduction, however, has been difficult for researchers to acquire because of inaccessibility of bowhead whales in their environment. My research has sought to obtain reproductive and life-history data from baleen using mineral, hormonal, and isotopic analyses. Baleen is an inert tissue that is formed from keratinized epithelium similar to nails, claws, or hair. Baleen can grow up to 4 meters in length and contain up to 20 years of growth from end to end. My initial objectives sought to determine differences between reproductive groups by analyzing hormones and minerals at the proximal end of baleen. Baleen was digested using nitric acid and minerals were analyzed using an inductively coupled plasma mass spectrometer. Concentrations of calcium in baleen were significantly lower in mature pregnant females than in non-pregnant females, (Tukey-Kramer adjusted $p = 0.022$). Correlation between length of whale and concentration of calcium was significant ($r = -0.503$, $p < 0.001$), but not significant in sexually mature whales that were over 14 m in length ($p = 0.721$). Stable isotopes of baleen correlate with annual migratory events of bowhead whales and thus provide a timeline for mineral and hormonal analyses along the length of the baleen. However, a series of calcium values from the baleen of individuals does not conclusively indicate pregnancy events. Hormones were extracted from powdered baleen using ether and measured using competitive binding assays. Concentrations of cortisol in baleen did not show significant difference between reproductive groups (pregnant and non-pregnant females); however, estrogen, progesterone, and testosterone are being analyzed. Analyses of baleen have shown promise as indicators of biological events in bowhead whales. More analyses of baleen are ongoing to identify reproductive events, including pregnancy, and identify correlations with length and other life-history parameters of bowhead whales. Results from these analyses will provide estimates of calving interval that will be important for management of this endangered species.

Can stable isotope ratios identify feeding events in bowhead whales?

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Bowheads (*Balaena mysticetus*) are endangered baleen whales adapted to life in the Arctic Ocean. They are culturally and nutritionally important to the Inuit peoples of Alaska and several circumpolar countries. During the fall 2011 subsistence harvest, we intensively sampled the alimentary tracts of 2 bowhead whales (1 subadult, 8.41m and 1 adult female,12.55m). Samples collected in the order of food passage were: forestomach, fundic chamber, pyloric chamber, duodenal ampulla, duodenum, jejunum, ileum, ileoceacal junction, upper colon, and colon. Stomachs of both whales contained a mixture of benthic prey, including isopods and amphipods, but only few euphausiids. Digesta were freeze-dried for 48 hours and analyzed for proximate composition (lipid, protein, caloric density) as well as stable carbon and nitrogen isotope ratios. Prey lipids were taken up in the duodenum with an efficiency of ~50%. Stable isotope ratios varied in a cyclic pattern along the digestive tract with d15N spanning over the range of 1 trophic level from 10.2-13.6‰ and 11.1-13.8‰, for the subadult and adult whale, respectively. Shifts in δ15N were accompanied by changes in δ13C, but carbon isotope signatures also corresponded to subsequent release and take-up of lipids in the bowhead whale digestive tract. Both whales showed 5 distinct stable isotope signature spikes in similar positions along the alimentary tract, i.e., forestomach, duodenal ampulla, duodenum/jejunum, ileoceacal junction, and colon. Based on published forestomach evacuation rates from minke whales (*Balaenoptera acutorostrata*) of 3-6 hrs and estimates of required annual energy intake by bowheads, we hypothesize that the observed stable isotope fluctuations resemble feeding events.

Comparison of data collected by digital sensors with observations made by humans

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In order to obtain permission from regulatory agencies in Canada and the United States to replace data currently obtained from manned aerial surveys with data collected from Unmanned Aerial Systems (UAS) it is essential to compare data from the two systems to evaluate biases in both data collection systems. If biases are more or less the same, or less, using the UAS, then regulators will likely authorize use of UAS to collect data currently collected by people in aircraft. During summer and fall of 2012 manned aerial surveys were conducted in de Havilland Twin Otters off the north and northwest coasts of Alaska at altitudes of 305 and 460 m above sea level (asl). During these surveys, high definition video (1920 x 1080) and digital single lens reflex cameras (7360 x 4912) were used to photograph the area within 300m (video) and 650 m (still cameras) either side of the aircraft track line when flights were conducted at 305 m asl. Areas covered were 1.5 times larger during surveys conducted at 460 m asl. Visual observations within the various swaths made by observers were compared to observations obtained from the digital media. Preliminary results from some of these comparisons are presented and recommendations are made on other analyses required and how to move forward with replacing manned aerial surveys with UAS and digital visual sensors.

Mapping Suitable Snow Habitat for Polar Bear Denning Along Alaska's Beaufort Sea Coast

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Polar bears are protected under the Marine Mammal Protection Act and are classified as "threatened" under the Endangered Species Act. Conservation measures for polar bears include efforts to avoid disturbing maternal dens, but this is challenging because they are difficult to detect. Polar bears along Alaska's Beaufort Sea frequently give birth to young in land-based snow dens, typically in deep snowdrifts that have developed in the lee of cut-banks found along streams, rivers, and the coast. The purpose of this project was to provide industry and regulatory agencies with more refined maps predicting suitable polar bear denning habitat. We incorporated 2.5-m resolution topographic data (obtained from LiDAR) and applied an existing model of blowing and drifting snow deposition (SnowModel; Liston and Elder, 2006) to more accurately predict the presence, timing, and evolution of snowdrifts in two simulation domains near Prudhoe Bay. Polar bears typically occupy den sites by late November, thus wind speeds and directions that occur during September, October, and November define which topographic slopes (e.g., SW or NE) the snow accumulates on, and thus define which slopes the bears den on in any given year. In this area, the coastal cut-banks are often only 2-m to 3-m high, leading to snowdrifts that are only 1.5-m deep, barely deep enough to accommodate a den. The total area within the simulation domains that is suitable for denning habitat (defined to be snow depths over 1.25-m resulting from NE and SW winds occurring during September, October, and November) is small: less than 0.1% of the land area in either simulation domain. There is a direct correspondence between the snowdrifts simulated by SnowModel and the historical den-site locations, showing that application of this model has the potential to improve efficiency and effectiveness of measures to reduce den disturbance. In association with this project, we developed a classroom-ready interactive presentation focused on polar bears, denning practices, and how they are changing over time. Project information was disseminated via the website of Polar Bears International, and we reported results of this work to four North Slope communities in October 2012.

Using aerial surveys to estimate polar bear abundance in the Southern Beaufort Sea

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Methods to estimate polar bear populations often involve physical handling of bears. Recently, other jurisdictions in Canada and Norway have been using aerial survey methods to estimate polar bear abundance. We investigated the potential for this method to be applied during the spring time in the Southern Beaufort Sea. We conducted a pilot study following mark-recapture distance sampling (MRDS) field protocols. We flew about 3,000 kilometers along transects oriented perpendicular to the coastline over the continental shelf (~100 km offshore) between Tuktoyaktuk, Canada and the US – Canada border. We observed 12 groups of bears (21 total individuals) while surveying. Analyses of these data suggest that, by flying 6 – 7 times more kilometers across the entire population, we would obtain an abundance estimate with a coefficient of variation of about 20%. Costs for the work would be high, but are still within the range of total costs in comparison to other methods. We note that aerial surveys do not provide the opportunity to individually identify bears, which is necessary for estimation of survival, nor do they facilitate the robust estimation of recruitment. This information is required for assessment of population status (i.e., growth). Further, the method does not allow for deployment of collars or collection of samples for a variety of studies to better understand polar bear health. However, an aerial survey can provide a systematic assessment of distribution and habitat use while yielding an abundance estimate relatively quickly. Communities and managers will have to weigh the relative benefits and limitations of abundance estimation methods for polar bears.

Historical and geographic comparison of ringed seal acoustic behavior in the Chukchi Sea and High Canadian Arctic

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Ringed seals produce distinctive underwater vocalizations that are thought to play a role in mating and in maintenance of social structure around breathing holes during periods of heavy ice cover. We analyzed recordings made offshore in the Chukchi Sea during April and May for the presence of ringed seal calls and logged key parameters of all calls detected. An identical analysis was performed on acoustic recordings collected by Ian Stirling in the High Canadian Arctic (HCA) in April and May of 1982. We compare the acoustic repertoire of ringed seals at both sites and find the same major call types present with little variation in call durations or frequency characteristics. However, the ratio of down yelps to other calls detected was substantially higher in the Canadian Arctic. The mean frequency of all yelp-type calls was also higher in the Canadian Arctic. During April and May, the mean number of ringed seal calls detected per minute was almost twice as high in the HCA as in the Chukchi Sea. This is most likely due to differences in the abundance of ringed seals at the two sites, but may also relate to differences in sea ice cover or other habitat characteristics, age class, or degree to which mating is occurring. We find the acoustic behavior of ringed seals to be consistent across widely separated geographic regions and a temporal scale of more than two decades.

Oil Spill Response for Polar Bears in Alaska

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Increasing ship traffic and oil and gas exploration in Arctic waters has increased the need for oil spill preparedness for Alaska′s marine wildlife, including polar bears. The U.S. Fish and Wildlife Service (USFWS) has management oversight for polar bears in Alaska and has developed a plan in cooperation with federal, state and local partners that provides response strategies for polar bears if an oil spill were to occur. Because of logistical challenges, safety risks, and lack of knowledge regarding effective cleaning and treatment methods, response strategies for polar bears emphasize preventative measures such as polar bear hazing and preventing oiling of important polar bear habitat. The plan also provides guidance on how to capture, handle and treat a small number of oiled (or otherwise compromised) polar bears. This guidance was derived in part from an experiment that was conducted in April 2012 to test methods for removing oil from polar bear fur. The experiment involved repeated trials of treating oiled 2-inch by 2-inch polar bear hide swatches with two water types (fresh and seawater) two water temperatures (60-70º F and 85-95 ºF), and two types of oil (heavy crude and light) at two weathering stages (fresh and weathered). Conducting the study helped identify the partners, equipment, and process that would be needed for cleaning and treating oiled polar bears. Limitations to this response strategy were also identified; the USFWS continues to work with its partners to address research and equipment needs.

Arctic - Mammals

Results from five years of aerial photographic data from the Bowhead Whale Feeding Ecology Study (BOWFEST)

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The Bowhead Whale Feeding Ecology Study (BOWFEST) was conducted August-September from 2007 through 2011 near Barrow, Alaska. This multi-disciplinary study, involving aerial surveys, acoustics, oceanography, tagging, and stomach sampling, included scientists from many institutions (National Marine Mammal Laboratory, University of Washington, Oregon State University, Woods Hole Oceanographic Institution, University of Rhode Island, University of Alaska Fairbanks, and North Slope Borough). The purpose of BOWFEST was to learn about bowhead whale feeding ecology during late summer in the Barrow area. The aerial survey component of this study focused on documenting the presence of bowhead whales throughout the area. Using NOAA Twin Otter aircraft, survey protocol was designed to provide randomized, representative sampling of the study area. In addition to trackline surveys, whales were photographed to provide information on individual bowhead whales. Photo-identification, based on unique scars on the dorsal surface of these whales, allows us to re-identify individuals within a season (indicating residence times) and across years (indicating temporal/spatial habitat preference of certain individuals). Photogrammetry provides length measurements of the whales, used as a proxy for age, thus providing the distribution of age classes within the study area. During the 5-year study, we took 1,605 photographs and, after matching, we identified 764 unique whales. Photographs of whales were also evaluated for evidence of feeding. When all 5 years were combined, 33% of the photos showed definitive evidence of feeding, 11% showed no definitive evidence of feeding, and in 56% evidence of feeding was inconclusive or photo quality was poor. There was considerable interannual variability in percentages of feeding whales (16%-50%) and age distributions (e.g., 2007: 77% adults vs. 23% juveniles; 2010: 7% vs. 92%). Although the inter-year matching effort is ongoing, we have already found one match of a whale photographed 8/23/07 and again on 9/2/09. Only three within year matches have been found (one whale photographed on 9/2/09 and 9/4/09; two whales on 9/9/11 and 9/13/11). Our BOWFEST photoanalysis shows no consistent individual fidelity to the Barrow area in late summer. This underscores the importance of this region to the entire bowhead whale population rather than small, distinct feeding aggregations.

Seasonal presence and variation in acoustic repertoire of beluga whales (*Delphinapterus leucas*) along the continental slope north of Pt. Barrow, from 2008 to 2010

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Satellite telemetry studies have shown that the continental slope waters of the Eastern Chukchi Sea are utilized periodically by beluga whales between spring and fall. However, little is known about the acoustic behavior of belugas in these areas or about their presence during winter months. We collected acoustic recordings from September through June of 2008 through 2010 120km north of Point Barrow, Alaska along the continental slope and analyzed them for the presence of beluga calls. Belugas calls were present at the study site from April to November in all years. Peaks in beluga acoustic presence occurred in May of each year, with notable episodic decreases in calls detected throughout May and throughout parts of June. We hypothesize that the temporary spring decline in beluga calls detected offshore may be related to the appearance of belugas in the lagoons along Alaska's North Slope. We also present a partial repertoire of beluga whistle sounds from analysis of key call parameters and investigate year-to-year and seasonal changes in the mean start and end frequencies for calls, as well as their durations. Analysis of call characteristics seasonal variations may provide a tool to help differentiate between Beaufort Sea and Eastern Chukchi Sea stocks when they are moving through this are where their ranges overlap.

Bearded seal seasonal use of continental slope habitat in the Chukchi Sea based on distance estimates to vocalizing individuals

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Bearded seals are ice-breeding Arctic phocids that prefer areas with 70-90% sea ice cover in water depths of less than 100m. However, continental slope waters greater than 100m in depth may also be an important habitat for this ice-breeding phocid species. We collected long-term acoustic recordings from the years 2007 through 2009 120km north of Point Barrow, Alaska at a depth of 274m and analyzed the received sound levels of bearded seal vocalizations in order to investigate their seasonal use of deeper slope habitat. Characteristic calls of bearded seals were logged and received levels calculated, based upon previous estimates of bearded seal acoustic source levels. We apply a propagation model to arrive at distance estimates for bearded seal calls received and compare distances of calling animals to local sea ice concentration and to direction of ice movement when possible. At all times of year, most bearded seal calls detected were 10 to 30 km from the recorder, presumably upslope in shallower water. However, occasional intense calling bouts were detected from animals within 5 km of the recorder. Statistical relationships between bearded seal call intensities and ice concentration are also presented. The results of this study suggest that although shelf waters less than 100m deep are the primary habitat for bearded seals, they occasionally utilize deeper areas.

Remote Biopsy Darting of Polar Bears: Implications for monitoring abundance, diet, and condition

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Remote biopsy darting allows for collection of samples from and genetic identification of animals without physical capture. Biopsy darting polar bears (*Ursus maritimus*) is less invasive and less time intensive than physical capture and is therefore useful when capture is impossible or challenging. We worked with two manufactures to develop biopsy darts specific to polar bears. We needed a dart that when fired from a dart gun could simultaneously dye-mark individuals, were remotely retrievable, and had brightly colored dart bodies to aid in recovery of samples. We had an 80% success rate of collecting a tissue sample with a single biopsy dart and we successfully collected tissue samples from a total of 143 polar bears on the land, in the water, and on the sea ice. We recovered darts from 11 polar bears in the water that we would not have been able to sample with traditional dart designs. Dye marks ensured that 96% of the bears were not resampled during the same sampling period and we recovered 96% of the darts that had been fired. Five and 7 mm-wide biopsy heads collected an average of 0.12 and 0.32 g, respectively of fur, tissue, and subcutaneous adipose tissue. Tissue samples were 99.3% successful (142 of 143 samples) in providing a genetic and sex identification of individuals. We had a 64% success rate of collecting subcutaneous adipose tissue and a 100% success rate using adipose samples to examine fatty acid signatures in 45 individuals. However, adipose lipid content values were much lower compared to values from immobilized or harvested polar bears indicating that our method was not suitable for quantifying adipose lipid content.

Industrial activities and western Arctic bowhead whales: what we have learned from satellite telemetry

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Offshore industrial activity is increasing within the range of the western Arctic stock of bowhead whales (*Balaena mysticetus*); however, how often individual whales encounter activities, and whether multiple encounters occur, has not been known. A satellite tagging study, funded by MMS/BOEM, tracked bowhead whales (2006–2010) to determine movements and habitat use, and minimum annual encounter rates of individuals with industrial activities. Most tagged whales made a >6,000 km annual migration, from the Bering Sea (winter range) through the Chukchi and Beaufort seas to the Canadian Beaufort Sea (summer range), and back. Their migration takes them through active oil and gas lease areas in U.S., Canadian, and (possibly) Russian waters. In summer, most whales (36 of 37) spend up to 3 months feeding in the Canadian Beaufort Sea, where 2D and 3D seismic surveys have been conducted since 2006. In fall, whales pass near or through active oil and gas exploration and development areas in the Alaskan Beaufort Sea. Each year, all tagged whales passed through at least one active industrial area and most (36 of 37) passed through two (one in the U.S. and one in Canada). One whale was documented within three seismic survey areas. The current level of activity has not prevented this population from growing; however, industrial activity is expected to increase, which will increase the frequency bowhead whales encounter industrial disturbances, which may have negative population-level consequences. Other potential effects are of concern to subsistence hunters, such as altered movement patterns. This study has demonstrated that individual bowhead whales currently encounter multiple industrial activities annually. Future studies will include the use of acoustic tags to determine individual bowhead call rates relative to ambient noise levels. Understanding bowhead call behavior will aid the interpretation of passive acoustic data currently collected near seismic and drilling sites.

A question of availability: Seismic sound affects the detectability of bowhead whales for visual detection

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Seismic sounds are known to alter the diving behaviour of bowhead whales (*Balaena mysticetus*), which in turn will influence the probability of detecting whales during aerial surveys. The consequences of altered detectability on assessments of distribution and abundance of bowhead whales are not well understood. Altered detectability could lead to under- or over-estimates of the numbers of whales present, as well as to incorrect conclusions about their distribution relative to seismic operations. We examined the influence of age, activity state and habitat on dive cycles to account for the altered probability of bowheads being at the surface of the water and available for detection by observers. Using behavioral data collected by government- and industry-funded aerial observation programs of bowhead whales conducted from 1980 to 2000, we calculated the mean surface and dive times for whales of different reproductive states and engaged in different activity states in summer and fall in the presence and absence of seismic sounds. The mean surface and dive times were combined with a field of view estimate specific to a de Hallivand Twin Otter aircraft to calculate the probability of bowhead whales being available for visual detection in the presence and absence of seismic surveys. We found that the availability of bowhead whales for visual detection varied with exposure to seismic sounds. Most notably, travelling whales and whales observed in the fall were less available for visual detection in the presence of seismic than in the absence of seismic. We provide correction factors for the altered availability of bowhead whales in the presence of seismic in the Beaufort Sea. Incorporating these correction factors into analyses based on aerial survey sighting data will provide more accurate assessments of bowhead density in the vicinity of seismic operations.

Do walruses eat seals when sea ice extent is at a minimum?

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Pacific walruses (*Odobenus rosmarus divergens*) depend on Arctic sea ice for a large portion of their life history. Sea ice provides a resting and diving platform for foraging and allows energetically-efficient access to benthic invertebrate prey along the Chukchi Sea Continental Shelf. However, it has been suggested that in nutritionally stressful situations or during unfavorable sea ice conditions walruses may prey on other pinnipeds. We applied stable carbon and nitrogen isotope values of walrus muscle tissues to a Bayesian mixing model (SIAR) to quantify feeding on higher trophic prey in walruses. Samples came from Native subsistence harvests, natural mortality events, and archived specimens (n=154) from the Bering Sea, Bristol Bay, and Chukchi Sea of Alaska. Mean contribution of higher trophic level prey (HTLP) to walrus diet was ~23% (± 0.1), which is higher than estimates based on historical stomach content analyses, but consistent with results from contaminant studies on Atlantic walruses (Odobenus rosmarus rosmarus). A general comparison between muscle data and historical sea ice extent indicates a positive correlation ($P<0.01$) between reliance on HTLP and ice extent. More detailed examination suggests a cyclical diet pattern. The possibility of a cyclical pattern is supported by oscillations in δ15N (~3‰) and δ13C (~2‰) values along the length of a whisker from a walrus sampled in 2011 with ringed seal (*Pusa hispida*) remains in its stomach. Analysis indicated periodic increases in the proportional contribution of HTLP to its diet. Our findings are contrary to the hypothesis that decreases in ice extent lead to walrus predation on seals and seabirds and suggest that walruses forage opportunistically as a result of multiple environmental factors.

Cetaceans of BOWFEST: Distribution near Barrow, Alaska, 2007-2011

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The Bowhead Whale Feeding Ecology Study (BOWFEST), funded through an Interagency Agreement between the Bureau of Ocean Energy Management and the National Marine Mammal Laboratory (NMML), conducted field operations from 2007 to 2011. The impetus was to minimize potential impacts from petroleum development activities by gaining a better understanding of bowhead whale (*Balaena mysticetus*) behavior and distribution. This was a multi-disciplinary study involving oceanography, acoustics, tagging, stomach sampling, and aerial surveys. Research focused on late summer oceanography and prey densities relative to bowhead distribution over continental shelf waters near Barrow, Alaska. The aerial survey component provided information on the spatial distribution of bowheads as well as other cetacean species, including: beluga (*Delphinapterus leucas*), gray (*Eschrichtius robustus*), and humpback whales (*Megaptera novaeangliae*). Sighting numbers were variable from year to year for bowheads (mean=44, SD=36, range: 16-103) and belugas (mean=23, SD=41, range: 0-95), but fairly consistent for gray whales (mean=19, SD=8, range: 6-26). Only one humpback whale was observed by the aerial team (in 2009). Each species distribution was calculated for all whale sightings (weighted by group size) over the 5-year period (using 1SD "Directional Distribution" ellipses in ArcView capturing ~68% of sightings). Overall each species occupied a unique region within the study area: bowheads on the continental shelf along the 20m isobath (in all years except 2011); belugas over the Barrow Canyon; and gray whales along the 50m isobath.

Arctic - Mammals

Sightings of Humpback, Fin, Minke, and Killer Whales in the Alaskan Arctic from Aerial Surveys in 2012

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Marine mammal aerial surveys were conducted in the Alaskan Arctic from summer through fall 2012, as part of the ongoing Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by the Bureau of Ocean Energy Management, with additional surveys targeting eastern Chukchi Sea belugas conducted in July in collaboration with the Alaska Beluga Whale Committee. The study area encompassed the western Beaufort and northeastern Chukchi seas (68°N-72°N and 140°-169°W), extending from the coast to approximately 315 km offshore. In addition to cetacean species typically seen by aerial marine mammal observers in this area, several species not commonly encountered were documented during the 2012 survey, including humpback, fin, minke, and killer whales. These four species were primarily sighted in two areas: nearshore between Icy Cape and Point Barrow, and west and south of Point Hope. None were seen in the western Beaufort Sea. Humpback, minke and killer whales were seen in both areas, whereas fin whales were seen only in the southern area. Most of the humpback whales were seen in the southern area, a region where gray whales have been reliably seen in past years. Humpback, minke and fin whales exhibited feeding behavior, and both fin and killer whale calves were observed. The killer whales were not observed feeding; however, several large whale carcasses were observed in the study area, one of which appeared to be missing its lower jaw, suggesting possible killer whale predation. None of these species were sighted during historical surveys flown from 1982 to 1991. Since broad-scale aerial surveys recommenced in the northeastern Chukchi Sea in 2008, the humpback, minke and fin whale sightings were limited to one fin whale in July 2008, one humpback whale in July 2009, and six minke whales in 2011. Although all of these species have been detected acoustically in the northeastern Chukchi Sea, particularly in the southern area, the historical scarcity of sightings from broad-scale aerial surveys is likely indicative of their relative rarity in this region. The 2012 ASAMM sightings may represent a continuing trend towards greater cetacean species diversity and abundance in the northeastern Chukchi Sea.

Polar bears from space: Evaluating satellite imagery as a tool to monitor *Ursus maritimus*

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While recent aerial surveys have provided scientists with a new tool to estimate polar bear abundance, the continued development of non-invasive and cost-effective research techniques remains a priority. Applications of remote sensing to study wildlife have become increasingly widespread, affording researchers access to difficult-to-reach sites without associated safety concerns and disturbance to wildlife. To evaluate the utility of high resolution (sub-meter) satellite imagery for monitoring polar bears, we implemented a small-scale pilot study in northern Foxe Basin, Nunavut, Canada. Foxe Basin provides an ideal scenario for assessing remote sensing methods for polar bears: recent comprehensive aerial surveys have documented that very high densities of polar bears are confined to relatively small islands (totaling <3,000 km2) with little topographic relief and no snow cover during the late summer, ice-free season. The pilot project included a ground-truthing, helicopter based aerial survey and the procurement of satellite imagery from selected islands in the study site. Preliminary results suggest that polar bears can be reliably identified from high resolution panchromatic satellite imagery in areas of low topography with a contrasting (dark) background. Additionally, we will evaluate detection probabilities on less contrasting (i.e., lighter) landscapes using both panchromatic and multi-spectral imagery. Data procured from the helicopter-based survey and satellite imagery will be used to generate independent estimates of polar bear abundance via distance sampling and manual counts, respectively. High resolution imagery shows initial promise as a tool for monitoring polar bear populations and distribution in high-density areas during the ice-free season. Consistency in detection, comparability of the abundance estimates, overall quality of the imagery and relative costs will be among the factors used to more thoroughly evaluate applications of satellite imagery in other regions and at broader geographic scales. Future research should focus on assessing imagery for polar bears in high topography sites and on-ice habitats.

Demography of the Pacific Walrus in a Changing Arctic

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Pacific walruses are relatively long-lived pinnipeds that are important to the Chukchi and Bering Sea ecosystems and to Alaskan and Chukotkan Native subsistence. Harvest is thought to have been the primary mortality factor affecting Pacific walruses for at least the past two centuries, but reduced availability of sea ice due to global warming may change the limiting factors for this population. In particular, it is hypothesized that the loss of late summer sea ice, which walruses use as a resting platform between foraging bouts, may reduce access to food, and through nutritional stress, may lower reproduction, calf and juvenile survival, and possibly adult female survival. We developed a Bayesian, hidden-state model of Pacific walrus population dynamics to provide new estimates of demographic parameters by formally incorporating information from five estimates of population size from surveys between 1975 and 2006, three estimates of population age structure from surveys between 1981 and 1984, and multiple decades of harvest estimates. Initial results suggest that reproduction and calf survival were low in the early 1980s when the population age structure data were collected, which is consistent with the population at that time being large relative to available resources. Ultimately, this model will be used to evaluate which demographic changes are most likely to affect walrus population size and growth rate and to generate field-testable predictions regarding the demographic effects of harvest and diminishing sea ice.

Matching landed bowhead whales to aerial photography

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Bowhead whales (*Balaena mysticetus*) are an important subsistence species for the Inuit peoples of Alaska. Whaling crews out of Barrow, the largest community on the North Slope, harvest approximately 20 bowhead whales annually. Scientists from the North Slope Borough, Department of Wildlife Management are collaborating with hunters to take measurements and tissue samples from landed whales. Abundance of bowhead whales in the Arctic Ocean is estimated by both of shore-based and aerial surveys. In the aerial surveys, high definition photographs are taken from above the whales to document unique markings on the dorsal surface and are then used to track individuals for mark-recapture. In this study, we selected well marked landed whales from photographs taken during harvest activities and attempted to match these individuals to aerial photographs. A match between landed and aerial photos would be helpful in ground-truthing measurements made from aerial photographs, estimating growth, and in corroborating reproductive status. Over 100 landed bowhead whales were analyzed, and whales with sufficient markings were compared to earlier aerial photos. Given the current population estimates (~12,600 in 2004) and the portion of whales in the population that are marked and cataloged, the likelihood of finding a match from photos that documented the complete dorsal surface is approximately 10.6%. However, because photos from landed whales where taken from a different perspective, the dorsal region was generally not photographed completely, and the likelihood of finding a match is functionally decreased. No definitive matches were found in this study, but one potential match was identified. Here, the body lengths measured in the aerial photograph (14.5 meters in 2003) and from the landed whale (14.9 meters in 2007) are within a reasonable range to be from the same animal. Though, due to the limitations of the different photographic angles, we cannot be certain that this is in fact a match. None-the-less, this exercise was helpful for improving future efforts to connect aerial data to on-the-ground sampling of harvested animals.

Potential population-level effects of increased haulout-related mortality of Pacific walrus calves

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Availability of summer sea ice has been decreasing in the Chukchi Sea during recent decades and increasing numbers of Pacific walruses have begun using coastal haulouts in late summer during years when sea ice retreats beyond the continental shelf. Calves and yearlings are particularly susceptible to being crushed during disturbance events that cause the herd to panic and stampede at these large haulouts but the potential population-level effects of this mortality are unknown. We used recent harvest data, along with previous assumptions about demographic parameters for this population, to estimate female population size and structure in 2009 and project these numbers forward using a range of assumptions about future harvests and haulout-related mortality that might result from increased use of coastal haulouts during late summer. We found that if demographic parameters were held constant, the levels of harvest that occurred during 1990–2008 would have allowed the population to grow during that period. Our projections indicate, however, that an increase in haulout-related mortality affecting only calves has a greater effect on the population than an equivalent increase in harvest-related mortality distributed among all age classes. Therefore, disturbance-related mortality of calves at coastal haulouts may have relatively important population consequences

Bering Sea - Ecosystem Perspectives

The incorporation of BSIERP field research into a vertically integrated modeling framework: what have we learned, and where are we going?

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As part of the multi-year Bering Sea Project (BSP), we implemented the Forage and Euphausiid Abundance in Space and Time (FEAST) model; the fish component of an end-to-end vertically integrated model based on dynamic prey fields, bioenergetics, and a suite of fish species. A key component of the Bering Sea Project was tight integration of observational field research and modeling. In 2011-2012, field researchers and modelers met several times in participatory workshops to compare and contrast model outputs to results from the BSP field years (2007-2010). In addition to improving model results, the meetings were designed to identify key sensitivities of the model for which limited data were available, provide feedback to field researchers in interpretations of observed patterns, and provide the basis for future field and modeling efforts. An early (and main) challenge was modeling fish survival over the annual boom and bust cycle of high ecosystem productivity in spring and summer followed by decreased productivity in fall and winter. Here, we present an analytical view of the assumptions needed to overcome winter mortality of fish and determine fish recruitment, given what we knew going into the modeling effort, what we learned through the incorporation of BEST/BSIERP field work, and what pieces of the puzzle remain to be uncovered. In particular, we discuss the timing of fish growth versus available zooplankton, the critical window of temperature and ice that determine fish growth, survival, and movement, energy reserves required for overwinter survival, differences in results between bottom-up and two-way coupled models, the overall modeled mechanisms that underlie correlative studies of field data, and the range of conditions over which those correlations may hold up in the future. Overall, this work represents a significant advance in understanding the dynamics of secondary production and the oceanographic effects on upper trophic level production in the Bering Sea; we will discuss what we learned from the model and identify outstanding gaps in our knowledge of the life cycle and spatial ecology of pollock, cod and arrowtooth flounder.

From Land to Sea: Building Conservation Partnerships to Alaska's Large Marine Ecosystems

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Landscape Conservation Cooperatives (LCCs) are self-directed partnerships that address applied science needs in the face of climate change and other landscape-scale stressors. Alaska is represented by five LCCs: Aleutian and Bering Sea Islands (ABSI), Arctic, North Pacific, Northwest Boreal, and Western Alaska. The steering committees of these LCCs include representatives of 40 Federal, State, Local, Tribal, and Non-Government Organizations. Although they are called "Landscapes," all five LCCs in Alaska contain coastline, and are actively pursuing applied science related to the coastal and marine environment, addressing resources including: salmon, shorebirds, seabirds and marine mammals. In the three years since their launch, these LCCs have funded nearly 100 projects with total expenditures of $8.4M and partner contributions of nearly $12M. As the most marine-focused of Alaska's LCCs, ABSI has funded studies investigating the impacts of climate change on seabird diets and shorebird migrations. The Western Alaska LCC is implementing a two-year pilot program that focuses on coastal storms and their impacts. The Arctic LCC has funded several nearshore projects, including studies related to fish migration, effects of glacial and humic run-off on coastal and estuarine systems, and coastal mudflat use by migrating shorebirds. The North Pacific LCC has funded a comprehensive literature review and synthesis of climate change effects on coastal and marine ecosystems in their region, and have identified sea level rise, coastal storms, and invasive species as priority research topics. And finally, the Northwest Boreal LCC, which includes major portions of the Yukon, Kuskokwim, Susitna, and Copper River watersheds, has a strong interest in marine issues as they relate to anadromous fish habit and life histories. The growing partnership communities for the five LCCs in Alaska are building bridges connecting marine and terrestrial environments through shared science needs and interdisciplinary collaborations. It is our hope that by integrating land and sea-based investigations, we can provide resource managers with the information at a landscape-scale perspective to sustainably manage resources that depend on both land and sea.

The Northern Bering Sea: Our way of life

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The Bering Sea Elders Group, made up of elders appointed by 39 tribes, collaborated with Alaska Marine Conservation Council to create maps of subsistence use in the northern Bering Sea and habitats important to species that tribal communities rely on. The purpose was to show the extent of culturally and ecologically important areas. Our report, *The Northern Bering Sea: Our Way of Life*, presents maps for walrus, seals, whales, eiders and fish compiled from interviews with elders and active hunters, Cenaliulriiit and Bering Straits Coastal Resource Service Area publications, and scientific data on species distributions. The report provides cultural dimension to the maps through excerpts from project interviews and traditional knowledge documents. The maps can inform natural resource policy decisions and support development of a long-term conservation regime that is responsive to traditional tribal values and local economies.

OBIS-USA: Building a resource for Alaska's marine biological data through community-supported standards and enrollment

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OBIS-USA (http://USGS.gov/obis-usa), a program of the United States Geological Survey Core Science, Analytics and Synthesis, is the United States regional node of the International Ocean Biogeographic Information System (http://iobis.org). Both International OBIS and OBIS-USA use Darwin Core (http://rs.tdwg.org/dwc/) as their biological data content standard for observations of biological occurrences, i.e. identifiable species at known time and coordinates, and includes data from all types of marine biological observations. OBIS-USA operates within a vibrant community of US agencies, scientists, managers and information technologists. Community engagement in the standards-building process ensures thorough discovery of diverse science and data requirements, opportunity for consensus building, and the real-world application orientation of OBIS-USA. Standards help users understand the quality and suitability of available datasets for specific applications, for example, by providing details about sampling methods and sampling conditions, a user may decide whether different datasets can be used comparatively. As a national resource, OBIS-USA spans the interests of local and regional communities in the coastal and offshore waters of Alaska and the Arctic, to US national scale priorities. For example, currently OBIS-USA provides access to records on over 450 marine taxa in the northern Bering Sea alone, with some records dating as far back as the 1880s. In addition to allowing such data discovery services, OBIS-USA attributes all data, as specified by contributors, and refers users back to data originators and other communities as applicable. Regional and national concerns become aware of each other through this resource, and national policy needs such as planning for ecosystem based management can greatly benefit from the efforts of regional communities. OBIS-USA brings new data aboard through a process we call 'enrollment'. Traditionally we assist new contributors with enrollment, to minimize effort and capture rich, documented, useful data. We are currently developing a wider spectrum of enrollment guides, tools, and technologies for repeat enrollers or those who want to self enroll. Alaska and the Arctic are a high priority region for US marine science and OBIS-USA welcomes new data participation and collaboration.

Alaska Corals: the case for Endangered Species Act listing

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Abundant and diverse, Alaska′s cold water corals may act as ′keystone′ species, playing a critical role in determining the diversity and abundance of benthic sea life in Alaska′s waters, as essential habitat for fishes, invertebrates, and other species. Alaska′s unique corals remain an enigma, with little scientific information about their geographical distribution, habitat requirements, role as fish habitat or function in the deep-sea ecosystem. Because of this, Alaska corals are at risk of ″silent″ extinction, disappearing even before they are discovered or described. Fisheries activities in Alaska continue to wipe out cold water corals at astonishing rates, destroying these slow to recover, long-lived ecosystems in a manner scientists describe as ″clear cutting the redwoods of the seas″. Recovery of coral communities damaged by fishing activities has not been observed and is estimated to take decades to centuries. In addition to fishing activities, a growing and long-term threat to Alaska corals are greenhouse gas emissions, which are already causing rapid changes in the marine ecosystem of the North Pacific and Bering Sea. Impacts from greenhouse gas emissions include ocean acidification, ocean warming and shifts in circulation patterns, with further changes predicted to occur if emissions continue under a business as usual scenario. Ocean acidification and ocean warming impact cold water corals by decreasing or changing surface productivity and water mixing patterns that provide food for the corals, by reducing the saturation levels of calcium carbonate used by corals for growth and repair, by reducing the amount of dissolved oxygen at depth, and by actively dissolving skeletal elements of the coral colonies. This presentation includes the most comprehensive cataloging of threats to Alaska corals to date, and describes updated research on Alaska coral biology and ecology, and on the changing conditions in Alaska′s oceans that will impact coral species. Using this information, we discuss why Endangered Species Act listing of 43 species of coral endemic to Alaska is warranted and also describe the protective measures that would be necessary to protect Alaska′s vulnerable corals from extinction.

Aleut ecological studies in Pribilof Domain – Highlights of marine investigations conducted by student researchers from the Pribilof Islands 2008-2012

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Aleut maritime cultural heritage imbues modern life in Pribilof Domain with a unique perspective on human interdependence with the Bering Sea ecosystem. Alaska's Pribilof Islands lie at the extreme southern extent of the seasonal Arctic sea ice zone – an island archipelago situated on the Beringian margin. Enriched waters at this crossroads of oceanic provinces are responsible for high biological productivity and Biodiversity. Students in the Pribilof School District have drawn upon ancestral knowledge relayed through elders to focus their scientific research on elements of the Bering Sea which shape transportation, subsistence food harvesting practices and economies for their island communities. We will present highlights of results of five years of collaborative research conducted in nearshore waters around St. Paul Island and St. George Island during spring and summer seasons by local school students. Our investigations confirm high species richness of nearshore flora and fauna. Stongylocentrotus sp. sea urchin population density, roe quality and roe percent of body weight continue to provide a rich, accessible resource for local consumption at St. George Island. Kelp species from the Class Phaeophyceae provide important canopy habitat around both islands and exhibit summer growth rates of approximately 11% per day. Golden V Kelp is distributed as far north as St. George Island in shallow subtidal patches, begins blade growth in March and begins to senesce in October. Zooplankton fueling the Pribilof Domain foodweb are typical of the middle and outer shelf assemblages; chaetognaths were dominant under late spring sea ice at St. Paul Island, and bioluminescent ctenophores dominated the watercolumn in midsummer at St. George Island. Fish, seal and sea lion stomach contents suggests a complex upper foodweb based on fish and crustaceans. Paralithodes sp. king crab adults and pelagic larvae are in very low abundance near the islands, but juvenile king crab observed in nearshore waters confirms that the Pribilof Domain still provides adequate juvenile "shellhash" habitat to support rebuilding of this economically important species.

The impact of sea-ice on bottom-up and top-down controls of crustacean zooplankton and the mediation of carbon and energy flow in the eastern Bering Sea

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Over the past decade, continued monitoring and multiple large-scale, comprehensive research programs have resulted in a wealth of data for the eastern Bering Sea, and provided an unprecedented opportunity to assess how this ecosystem responds to multi-year periods of cold and warm conditions. It is becoming evident that the presence or absence of sea-ice in spring is the single most important component determining the physical and biological structure of the shelf ecosystem, not only in spring, but through the summer. Additionally, large crustacean zooplankton (LCZ) appear to be a biological choke-point for the flow of energy through the pelagic ecosystem. Associated with a warming climate are predictions of dramatic reductions in sea-ice extent and re-partitioning of carbon and energy flow within this ecosystem. This synthesis program draws upon the large data sets collected during BEST/BSIERP as well as historical data to address the question: How does the presence or absence of sea-ice over the eastern shelf in spring influence the flow of energy through the pelagic ecosystem in the eastern Bering Sea, particularly the distribution, standing stocks, and trophic roles of large crustacean zooplankton that are of critical importance in the diets of commercially valuable fish, marine birds and cetaceans? Our approach is to analyze bottom-up and top-down controls of LCZ standing stocks, including climate, physics, primary production, micro-zooplankton production, and predation, and to examine how secondary production is partitioned among top predators under varying climate scenarios.

Spatiotemporal variation in carbon availability and uptake in the Bering Sea benthic food web: Evidence from invertebrate fatty acids

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The Bering Sea contains several of the most productive benthic communities in the world ocean. These seafloor communities are primarily sustained by input of sea ice or pelagic algal detritus, but may also rely on benthic microbial biomass, terrestrial organic matter, and microphytobenthos, depending on site location and time of year. To assess seasonal variation in benthic carbon supply and document species-specific differences in assimilation, we analyzed a suite of fatty acid (FA) biomarkers indicative of carbon source in sediments and benthic invertebrate tissue (e.g. *Macoma calcarea*, *Nuculana radiata*, *Leitoscoloplos puttagensis*, *Nephtys* sp.). Relative concentrations and stable carbon isotope signatures of FAs, including eicosapentaenoic acid (EPA), from sediment, ice and pelagic particulate organic matter (I-POM and P-POM, respectively) were used to identify the relevance of carbon source for benthic invertebrate diets during conditions of maximum sea ice extent, ice melt, and ice free surface waters. Sample collection was carried out in the Bering Sea in 2009-2010 as part of the Bering Ecosystem Study (BEST). Based on δ13C values of EPA from sediments, seasonal patterns in benthic carbon source were obscured by high spatial variation across the shelf (~4-5 ‰ difference between sites within a given season). Bivalve δ13CEPA values consistently fell within 1 ‰ of sediment values at a given location, suggesting that they assimilate accessible carbon, irrespective of source. In contrast, polychaete EPA was consistently enriched in 13C by ~3-4 ‰ relative to sediment EPA, indicating selective assimilation of isotopically enriched microbial biomass and products.

'Deadliest' threats: addressing six regional environmental stressors facing the Aleutian and Bering Sea Islands

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The Aleutian and Bering Sea Islands Landscape Conservation Cooperative, or ABSI LCC, is one of a network of 22 public-private partnerships providing shared science to ensure the sustainability of America's land, water, wildlife and cultural resources. The ABSI LCC is a growing network of regional partners who have come together to promote coordination, dissemination, and development of applied science to inform conservation of natural and cultural resources in the face of climate change and other landscape-scale stressors. We aim to identify and support research --including data collection, analysis, and sharing that addresses common information needs and connects the efforts of marine and terrestrial managers. Following our establishment in 2011, a key focus has been the development of a strategic science plan that will guide our efforts for at least the next five years. Plan development began with the compilation of over 40 existing research and management plans relevant to the Aleutian and Bering Sea Islands region. These plans range from single and multi-species plans to those proposing strategies for ecosystem-wide management. Collectively they represent a rich legacy of effort from countless resource managers and researchers working in the region over decades. Through an analysis of these plans we have identified six landscape-scale environmental threats—or stressors, facing the region: Climate Variability and Change; Marine Shipping; Invasive/Introduced Species; Ocean Acidification; Contaminants and Pollutants; and Commercial Fisheries. We present a list of applied research needs to address these stressors for your review and are asking for your perspectives to improve our efforts toward integrated, strategic science planning in the Aleutian and Bering Sea Islands region.

Understanding the link between Alaska and Canada's interior forests and healthy, productive marine systems

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Landscape Conservation Cooperatives (LCCs) are self-directed partnerships that provide science and support for conservation and sustainable-resource management to address landscape-level challengers or stressors, such as climate change, that no one agency or organization could address alone. LCC partnership communities are composed of federal and state agencies, Tribal, First Nations, and local governments, non-governmental organizations, universities, and others. LCCs recognize that many landscape-scale stressors transcend political and jurisdictional boundaries and require a more networked approach to conservation and sustainable management – holistic, collaborative, adaptive, and grounded in science. The Northwestern Interior Forest (NWIF) LCC is one of 22 LCCs in North America. It includes the boreal and boreal transition zones in Alaska, Yukon Territory, western Northwestern Territories and northern British Columbia, as well as major portions of the Cook Inlet, Yukon, Kuskokwim, Susitna, and Copper River watersheds. The NWIF LCC is in its formative stages and is conducting an Information Needs Assessment (INA) in which the LCC will work with partners to determine commonalities in what natural resource information is needed, at what scale, and in what format, to inform local and landscape management and planning across the region. Although early in the INA process, NWIF LCC recognizes the intrinsic links between terrestrial, aquatic and marine ecosystems in supporting healthy, sustainable salmon populations. To maintain a holistic view of the drivers and stressors that affect salmon habitat, health, and the communities that depend on them, the NWIF LCC will consider the linkages between marine and terrestrial systems when supporting science to inform management. Moreover, Alaska LCCs can work jointly to address the effects of climate change and other stressors on anadromous fish in all life history stages.

Bering Sea - Ecosystem Perspectives

Identifying and comparing ecosystem stressors in the eastern Bering Sea and Gulf of Alaska

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To address demand for ecosystem-based approaches to resource management and to provide a framework for scientific assessment at the ecosystem level, NOAA has recently implemented a national program of Integrated Ecosystem Assessments (IEAs, Levin et al. 2009). In each of the Large Marine Ecosystems, an IEA is regionally specific, allowing managers to tailor IEA components (objectives, indicators, risk and ecosystem assessments, and management strategy evaluations) to the focal ecosystem. An important component of the IEA process includes developing ecosystem indicators and targets for conducting risk analyses. The eastern Bering Sea (EBS) and Gulf of Alaska (GOA) are large marine ecosystems located at similar latitudes and separated by the Alaska Peninsula. The EBS habitat is dominated by a broad, soft-bottom continental shelf, whereas the GOA habitat is a diverse mix of rocky shelf, canyon and deep water. Each is host to a similar suite of species, but has fundamentally different food-web structure and function. Both ecosystems are exposed to multiple natural stressors and anthropogenic activities that include direct and indirect effects of fishing and climate change. In this study we develop metrics to represent the condition of these marine ecosystems that can be used (1) to establish reference points useful for Alaska's IEA and (2) to enable comparisons across ecosystems. We modify recent ecosystem index approaches (e.g., the Ocean Health Index by Halpern et al. 2012) to reflect conditions and stressors that are particular to Alaska, apply the index assessment to data collected from surveys of Alaska marine ecosystem experts, and conduct comparative analyses between the EBS and GOA ecosystems.

Bering Sea - Humans

Trichinellosis in marine mammals as a zoonotic disease, and possible ways of transmission of trichinellosis to humans in the Chukchi Peninsula

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Subsistence hunting of marine mammals is one of the primary sources of food for the indigenous Chukchi communities, however, the health risk associated with consumption of Trichinella infected marine mammal meat is of concern. Infection prevalence and intensity were measured by the compression and artificial digestion methods. Of 334 carcasses from mammals and birds examined for Trichinella larvae, the following species were infected: bearded seal (4.3%), ringed seal (1.6%), brown bear (80.0%), fox (66.7%), farmed polar fox (72.3%), stray (92.8%) and sled dogs (68.4%), domestic cats (88.9%), Norway rat (40.0%). Trophic and chorological ties were studied. Role of invertebrates in the circulation of trichinellosis is discussed. Of 159 and 100 humans tested by enzyme-linked immunosorbent assay (ELISA) in the communities of Lorino and Lavrentiya, 46 cases (28.9%) and 17 cases (17.0%) tested positive, respectively. All the cases were asymptomatic carriers. The titers varied from 1:100 in 20 cases (31.7%) to 1:1600 in 4 cases (6.3%). Seropositive individuals were analysed with respect to their sex, age, occupation and nationality. The ELISA assay using excretory-secretory antigens to the Arctic strain of Trichinella has been shown to be 3.2 times more sensitive than a commercial ELISA assay using excretory-secretory antigens to T.spiralis. Trichinella larvae in kopal′khen preparation stored at -12-14˚C remained infective for 4.5 years. Larvae remained viable for 21 days in fermented meats stored at +4 C but did not survive after 5-6 days in dry-cured meat (weight loss 4-5 times of the initial weight). Trichinella preventive measures were developed.

Bering Sea - Humans

Climate change and fisher behavior in the Bering Sea pollock trawl and Pacific cod longline fisheries

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The two largest volume commercial fisheries in the US Bering Sea are the pollock and Pacific cod fisheries. In this paper, we build upon work that independently examined the impact of climate change on the pollock and Pacific cod fisheries. We examine how both fisheries have adjusted to economic and environmental variation since 2000. For pollock, the mean location of winter fishing has varied little in warm and cold years, but there has been a northward shift in summer pollock biomass and fishing. This shift is related to the colder than average climate conditions in the latter part of the decade. For Pacific cod, the timing and location of winter fishing has shifted dramatically since 2000.This shift is related to the extent of seasonal sea ice and the timing of its descent and retreat. The summer Pacific cod fishery also shifted to the north, although the timing of the season remained constant. Climate affects relative spatial catch-per-unit-effort (CPUE) in both fisheries by causing a cold pool (water less than 2°C that persists into the summer) that sub-arctic species such as pollock and Pacific cod avoid. Understanding the relationship between fishing location, climate variables, and economic factors is essential in predicting the effects of future warming on the pollock and Pacific cod fisheries. We discuss key differences in our understanding of fisher behavior, climate conditions, and spatial changes in fish abundance in the two fisheries. This work is part of the Best-BSIERP Ecosystem Partnership.

Bering Sea - Humans

Updating the nautical chart in Nushagak Bay

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The National Oceanographic and Atmospheric Administration (NOAA) contracted TerraSond, Ltd. to update the nautical chart for Nushagak Bay in Bristol Bay, Alaska, currently based on data from 1950. The final project area consisted of nearly 172 square nautical miles and stretched from Etolin Point to Snag Point in Dillingham. This area includes many sandbars, has tidal and river currents exceeding 5 knots and experiences a maximum tidal range of nearly 9 meters. Users of this waterway include barges which bring supplies to Dillingham, commercial and subsistence salmon fishing fleet and tenders, and local small boat traffic between villages. TerraSond utilized three small survey vessels which returned to Dillingham daily for crew relief, food and fuel. Due to the shallow depth of this area (for the most part less than 20 m), single beam echosounders were more cost- and time-effective than either mutibeam or side scan sonars. From mid-May through mid-August, the vessels ran a total of 3,865 linear nautical miles of data at 100 m spacing perpendicular to the predominant channel shape. Three tidal stations were installed by a subcontractor, JOA Surveys, to provide accurate tide modeling for the project. Due to lack of Differential Global Positioning System correctors in Western Alaska, TerraSond set up four Real-Time Kinematic (RTK) GPS stations. The RTK stations broadcasted GPS corrections for use during data acquisition and recorded data to be used in post processing. Post-processing GPS data using RTK station data achieved vessel positioning accuracy to better than 10 cm. Challenges were incurred not only due to the large size of the survey area, but also due the area's exposure to weather, fishing fleet operations, and the tidal limitations of the small boat harbor in Dillingham. TerraSond will complete data processing for this project in December of 2012. NOAA will review data, make changes to the chart and typically publish new charts within 2 years of contractor submission.

Bering Sea - Humans

Pribilof Islands, Alaska community based king crab ecological and economic research program

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Alaska's Pribilof Islands lie at the extreme southern extent of the seasonal Arctic sea ice zone and are in the core area for Bering Sea king crab distributions. Pribilof communities enjoyed economic prosperity from king crab fisheries in the 1980s and 1990s through their involvement in processing, harvesting and activities associated with these lucrative fisheries. Two key species, the Pribilof Blue King Crab (*Paralithodes platypus*) and Red King Crab (*Paralithodes camtschaticus*) stocks have declined precipitously. Pribilof blue king crab harvests exceeded 11 million pounds in the 1980s but fisheries were closed in the 1990s; the stock was declared overfished in 2002. The multimillion dollar red king crab fishery was reduced in the 1990s and is now closed. Students of the Pribilof Island School District examined the economic value of crab fisheries and initiated ecological studies in 2007 to address gaps in knowledge on early life history stages of king crab, their habitat needs and effects of environmental variables on young crab. Nearshore plankton tows, larvae traps, juvenile crab intertidal surveys and subtidal investigations using pots, Remotely Operated Vehicles and other technology confirm that pelagic larvae are scarce but juvenile king crab continue to occupy waters of Pribilof Domain. Yet the lack of recovery for Paralithodes king crab remains unclear, and examination of effects of climate, fisheries, habitat integrity and other aspects of crab ecology are being pursued. Results of this continuing research are informing local, state, federal and hatchery efforts to restore Pribilof king crab populations and their economic contribution to Pribilof communities in the future.

Bering Sea - Humans

An alternative ecosystem based management strategy for the Bering Sea shelf edge – historic and scientific basis for the tribally-nominated Pribilof Domain Cultural Heritage Zone, a Marine Protected Areas approach for sustaining fisheries and communities

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The scientific basis for spatially explicit marine management measures to sustain ecosystem functions is well documented in science and marine policy literature. Alaskans have applied area based management measures throughout State and Federal waters to address specific species or habitat concerns since Statehood, with varying degrees of success in achieving management objectives. Pribilof Domain was initially recognized for outstanding productivity and the need for spatial management measures in 1893, when a 60-mile zone around the islands was established as the first international wildlife protection measure. The area was then, and is now, considered critical foraging grounds for nursing and young northern fur seals, and the ecosystem upon which they depend. The National Marine Fisheries Service, the North Pacific Fisheries Management Council EFH committee, Non-Governmental scientists and others have advanced various alternatives for protecting selected species and habitat types along the shelf edge. Yet these efforts have not resulted in the recovery of key species in Pribilof Domain, such as king crab and northern fur seals. Further, the human population and economy have continued to decline. For this reason, the Tribal government of St. George Island has advanced a new ocean management strategy for Pribilof Domain. The core objective of the Pribilof Domain Cultural Heritage Zone is to sustain the ecological function and connectivity from Pribilof Canyon to waters encircling the Pribilof Island Archipelago and provide community access to fishery resources to support the local economy and cultural identity of the Aleut people.

Bering Sea - Humans

Navigating Change in Iŋalit – Walrus Relationships

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This poster presents information on the topic of change in the context of walrus and Iŋalit (Little Diomede residents) relationships with them. This data was collected during the Iŋalit Traditional Knowledge of Walrus in the Bering Strait project, which is a collaboration between Kawerak and the Native Village of Diomede, as well as through several other ongoing projects in the region. The poster will focus on insights from traditional knowledge and observations of Diomede residents about changes in walrus behavior, timing and location of migrations and haul outs, population numbers, environment (e.g. ice, currents), hunt abundance, hunting practices and use. While the connection between walrus and Iŋalit lifeways remains strong and locally vital, there appear to have been substantial and systemic impacts to this relationship connected with environmental changes.

Bering Sea - Climate and Oceanography

High-resolution modeling of the Eastern Bering Sea

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A 2-km scale, high-resolution model of circulation in the eastern Bering Sea has been developed and analyzed to better understand eddy variability and heat transport around the Aleutian Islands, the Bering Sea Basin and the Eastern Bering Sea Shelf. Simulations with realistic atmospheric and tidal forcing are performed for Summer/Fall 2009. The modeled sea surface height compares favorably with alongtrack altimetry from Envisat for the same period. Surface temperatures and temperature gradients are consistent with satellite derived sea surface temperature patterns. The contrast between simulations with and without tidal forcing shows the critical role that tides play in establishing the Aleutian North Slope Current and the eddying characteristics of the Bering Slope Current downstream. Tidal forcing is also found to significantly improve model performance in capturing sea surface height patterns south of the Aleutian Islands where domain boundary effects can introduce errors otherwise. Temporal variability of transport through the straits is investigated to determine how tides, variations in the Alaskan Coastal Current, and storms influence the characteristics of the Aleutian North Slope Current and the Bering Slope Current.

Bering Sea - Climate and Oceanography

Variability of the Bering Slope Current

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The Bering Slope Current (BSC) is a dominant feature of the circulation of the Bering Sea, comprising the eastern boundary current of the cyclonic gyre. The current has been described using various in situ datasets including hydrography, moorings, and drifters. Each of these datasets was limited in spatial and temporal coverage and significant questions regarding the variability of the current still exist. For example, while moored current meter measurements suggest no significant seasonal cycle, model results suggest a significant seasonal cycle in transport and position of the current. Nineteen years of satellite altimetry data allow an analysis of seasonal and interannual variability of the BSC. These data illustrate that the BSC is stronger and overlies the slope during winter and weaker, overlying the deeper basin during summer. While a net northwestward flow exists when averaged over sufficient timescales, mesoscale variability conceals the signal on shorter timescales. Variability of the BSC is associated with climate patterns such as the North Pacific Index. These correlations and their implications will be discussed.

Bering Sea - Climate and Oceanography

Acoustic estimation of relative zooplankton abundance in the Eastern and Western Bering Strait

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Pathways of zooplankton advection through the Bering Strait may also be important migration corridors for the bowhead whales that feed upon them. Such pathways can be identified using Acoustic Doppler Current Profiler (ADCP) backscatter data to find areas of high diel vertical migration (DVM), characteristic of bowhead prey zooplankton species, such as the euphausiids Thysanoessa raschii and T. inermis. It has been proposed that the euphausiid population of the Beaufort Sea originates in the western Bering Sea, and is advected through the Bering Strait, however it is not clear which side of the strait might carry the bulk of the zooplankton transport. Traditional ship-based sampling cannot adequately address this issue. Data from two ADCP moorings on opposite sides of the Bering Strait are analyzed to identify timing of highest acoustic backscatter, as well as to compare relative amplitude between years from 2005-2008. Highest acoustic backscatter was observed during September and October for all years on both sides of the strait. Relative backscatter intensity was similar on both sides of the strait, and was highest during 2005 and 2006, and lowest during 2008. The similarity in relative backscatter intensity between moorings suggests that transport of zooplankton was evenly distributed on both sides of the Bering Strait, and that source waters were well mixed before entering the strait. The relationship of these patterns to prevailing wind and current conditions is explored, as well as their relationship to data from nearby moorings.

Bering Sea - Climate and Oceanography

Estimates of the volume transport in the Eastern Bering Sea shelf through 4Dvar data assimilation of hydro-physical data

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Circulation in the North-Eastern Bering Sea shelf in 2007-2008 was reconstructed through the 4-Dvar data assimilation procedure. The relatively high spatial resolution (6-9km) used in the Semi-Implicit Ocean Model (SIOM) allow for accurate estimation of the volume transport in the investigated region. Used together with a Data Assimilation System (DAS), this allows allows for assimilation of temperature, salinity, and velocity data obtained from mooring arrays and available CTD observations in the Bering Strait and central Bering Sea. Climatological T/S fields and Sea Surface Height (SSH) obtained through the Copper-Haines algorithm were used as background data. The reconstructed circulations were additionally validated with respect to available velocity field observations which were not assimilated into the model.

Bering Sea - Climate and Oceanography

Linking scientists, decision makers, and organizations to improve understanding of climate-driven changes in coastal storms and their impacts in Western Alaska

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The coastal zones of Western Alaska are expected to experience a nexus of climate-driven changes in landform processes resulting from the impacts of sea ice loss; sea level change; permafrost thaw; changes in frequency, intensity, and direction of coastal storms; etc. These climate-driven changes will cascade through the near-shore and coastal physical systems, ecological systems, and human communities, and thus present major sources of uncertainty for a wide variety of the region′s decision makers. To effectively and efficiently address some of the information needs of these decision makers, the Western Alaska Landscape Conservation Cooperative created a two-year program of applied science focused on ′Changes in Coastal Storms and their Impacts′. We summarize program components that successfully advanced applied science to address these decision maker information needs. All the components share a common feature of promoting linkages: (i) among resource decision makers, stakeholders and scientists, to identify and address key areas of uncertainty associated with coastal storms and thus align the science activities with decision maker needs for a variety of climate vulnerability assessments; (ii) among researchers, to mutually advance their science efforts; and (iii) among organizations, to efficiently address shared science needs. Resulting applied science benefits include (i) integrative projects using very fine resolution surge modeling to assess impacts of saltwater inundation on migratory waterfowl breeding populations and habitat; (ii) coordinating the selection of historic storms for reanalysis by two surge modeling efforts of differing resolution and domain, thus allowing for cross-model comparisons of performance over their shared spatial domain and future regional-scale application of the higher resolution model; and (iii) collaborative, cross-agency efforts to establish a water level network that meets multiple purposes (from model calibration to emergency response to wildlife management) in a region where none currently exists.

Bering Sea - Lower Trophic Levels

Assessment of red king crab in eastern Norton Sound

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Year one of a three year study examining movement, size composition, potential essential habitat, and handling rate of red king crab Paralithodes camtschaticus in eastern Norton Sound was completed. In this study red king crab were tagged and released in the spring and recovered during the summer commercial fishery. Catch observers were place on commercial vessels to help recover tagged crab and monitor catch composition. Eight vessels voluntarily participated in an observer program and an additional 4 vessels collected tagged crab information in lieu of an observer. Over the 44 day commercial fishing season, 3 observers made a total of 31 trips, recovered 60 tagged crabs, and examined 106 crab pots for species compsoition. Within commercial crab pots, 19 different species (predominantly invertebrates) were identified and red king crabs (all sizes) were the most abundant species in the majority of the crab pots. The next most abundant organism was the purple-orange sea star Asterias amurensis. Other species present generally did not exceed 5 individuals per pot. Handling rate of red king crab varied by escape mechanism. In pots configured with a large mesh panel (23), target crab made up 75% of the catch while in pots configured with escape rings (83) target crab made up only 36% of the catch, increasing the handling rate of non-target crab. However, pot location may affect species composition, thus handling rates, and will be examined in the near future. Data analysis is ongoing and will include examining movement of red king crab using tag recovery data collected from observers, vessel captains, and processors. Additionally, comparisons will be made between harvest model inputs and newly collected commercial fishery data, and tagging locations will be evaluated for possible breeding and rearing habitat.

Current knowledge on the ecology and taxonomy of the early life stages of arrowtooth (*Atheresthes stomias*) and Kamchatka flounder (*A. evermanni*) in the eastern Bering Sea

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Arrowtooth flounder (*Atheresthes stomias*; ATF) are large, predatory flatfish that occur in the eastern Bering Sea (EBS). Early life history studies of ATF in the EBS have been difficult due to the presence of Kamchatka flounder (*A. evermanni*: KF). As adults, ATF can be separated from KF by morphological and meristic characters, however, in the larval and early juvenile stages these two species have been identified only as the species complex Atheresthes spp. The purpose of this BSIERP project was to identify larval and early juvenile Atheresthes spp. to the species level and to study their distribution, abundance, and approximate energy density (% lipid content). To accomplish this, a genetic technique was developed based on mtDNA cytochrome oxidase subunit I (COI). With this technique, 165 ATF and 194 KF larvae and early juveniles were identified from BSIERP and AFSC cruises (2006–2010). All specimens genetically identified to species were then examined to assess unique pigmentation and morphological characters. Results indicate that small larval specimens (6.0–12.0 mm SL) and larger specimens (≥20.0 mm SL) can be identified to species using visual identification methods. The distribution of larval ATF and KF is very similar and they are often collected in the same hauls, but juveniles (≥25.0 mm SL) appear to separate slightly with juvenile ATF occurring more on the shelf than juvenile KF. Initial data on % lipid content of larvae and juveniles indicate that larval KF have higher % lipid content than larval ATF. Additional work is necessary to be able to visually identify specimens 12.0–20.0 mm SL, and to give further evidence of the differences in abundance, distribution, and energy content between these two species.

An Annotated Checklist of the Marine Macroinvertebrates of Alaska

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A comprehensive species list of marine invertebrates of Alaska is currently lacking. The checklist of Austin (1985) treated the marine invertebrates of Southeast Alaska to California and since then many new species have been described, many range extensions have been discovered, and considerable changes in higher-level systematics have been made. The checklist we compiled lists over 3,500 species and includes the currently accepted scientific name and its significant synonyms, common names, type localities, geographic and depth distributions, a general statement of abundance (e.g., rare, uncommon, common, abundant), significance for fish habitat, and general remarks. This checklist will serve as a foundation for future species-specific research. Updated species lists are necessary to reflect the current state of biodiversity knowledge and are thus essential for conservation planning and management. To monitor and predict future changes to marine life, the distribution and abundance of marine species need to be better understood, and this can only be achieved with reliable identifications based on a sound taxonomy. The current status and future directions of Alaskan marine invertebrate biodiversity are briefly discussed.

Importance of sea ice versus water column production for zooplankton consumers in the Bering Sea

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With variable sea ice cover in the Bering Sea due to climate change, the importance of sea ice algal production for pelagic consumers was investigated during BEST/BSIERP cruises in 2008 and 2009. The stable isotope (nitrogen and carbon) ratio of particulate organic matter (POM) from the water column and sea ice (where present) and of zooplankton organisms (Calanus glacialis/ marshallae and Thysanoessa rashii) were compared for late spring during broken ice cover. Both zooplankton species had similar nitrogen ratios, indicating that they were feeding on a comparable trophic level. However, krill were enriched over copepods by about 0.5-2‰ in carbon stable isotope ratios, indicating their feeding on a different carbon source. Based on the overall enriched sea ice POM carbon stable isotope ratios compared to water column POM, mixing models suggest that krill are feeding 10-35% more on sea ice POM than copepods.

Reproductive potential of snow crab (*Chionoecetes opilio*) in the eastern Bering Sea: patterns observed in female sperm reserves, 2007 – 2012

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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 possess sperm storage organs, and if they receive sufficient sperm reserves during mating, they can produce fertilized egg clutches over multiple reproductive cycles. Measures of female sperm reserves were taken in 2005, after which a monitoring study was developed that has allowed for an annual evaluation of this index of female reproductive potential through the EBS snow crab distribution since 2007. Spermathecal load (SL) of 1,026 primiparous snow crab collected between 2007 – 2011 and processed for sperm reserves ranged from 0 to 0.5875 g and averaged 0.0488 g. Significant relationships were detected between SL and female size, year, and area of collection (as defined in three regions), as well as interactions among these factors. The highest levels of SL were observed in the southeast area and the lowest levels were observed in the northwest area. The majority (88 %) of primiparous snow crab from the EBS had sperm reserves of less than 0.1 g SL, which is low in comparison to levels reported from snow crab in the Northwest Atlantic. Preliminary analysis of SL of 525 multiparous snow crab collected and processed over this same time frame ranged from 0 to 1.2415 g and averaged 0.1015 g. Most multiparous females (66 %) had sperm reserves of less than 0.1 g SL. Though subjective evaluation of egg viability indicated most primiparous females in our study received sufficient sperm to fully fertilize their first clutch, the amount of remaining stored sperm indicates that many would likely need to re-mate in order to produce subsequent fertilized egg clutches. Differences observed in SL between spatial regions underscore the importance of understanding how spatial processes affect snow crab in the EBS. Samples collected in 2012 are being processed and data will be incorporated into this analysis as time allows.

What controls euphausiid distribution in the eastern Bering Sea?

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The controlling factors of euphausiid distribution were studied in the eastern Bering Sea during 2008-2010. Quasi-Poisson generalized additive models were applied to explore the effects of controlling factors. Three major euphasudiid species-- *Thysanoessa raschii*, *Thysanoessa inermis*, and *Thysanoessa longipes* showed different spatial distribution patterns as well as different relationships with the environmental factors. *Thysanoessa raschii* distribution was significantly related to bottom water temperature, bottom salinity, and chlorophyll a concentration; *Thysanoessa inermis* distribution was related to bottom water temperature and bottom salinity; *Thysanoessa longipes* distribution was related to bottom salinity. Walleye pollock density affected euphausiid distribution only in the outer region (>100m). As an index of ocean conditions, the thickness of sea ice in the north region of the eastern Bering Sea (60°N~65°N) in spring was positively related to the abundance of euphausiids in summer. West-east ocean current velocity near Pribilof Islands in the outer region (172°W, 56°N) positively controlled the ratio of euphausiid abundances between the deep water (>100m) and shallow water (<100m). Ocean conditions affected outer shelf species (*T. longipes*) and inner-middle shelf species differently, accordingly the proportion of their abundances in the total abundance varied interannually. Our study suggests that euphausiid distribution was controlled by multiple factors at different scales (regional scale and sub-regional scale), including both bottom-up forcing and top-down forcing.

Bering Sea - Fish and Fish Habitat

Defining ecological regions in marine systems: synthesis of physical structure and community composition to inform spatial management

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Understanding spatial structure in marine systems and delineating meaningful spatial boundaries is integral to ecosystem approaches to fisheries management. We develop and apply multivariate methods to define spatially coherent ecological units or ecoregions, as one approach to defining management units in large marine ecosystems. Physical structure and physical forcing mechanisms combine with biological responses and interactions at the species level and within communities to organize marine systems in unique ways at multiple spatial scales. We examine the role of habitat in moderating species distributions and interactions. We use random forest and other multivariate methods to assess the importance of habitat in defining species distributions and quantify the importance of dominant physical variables for individual species. We also quantify multi-species composition turnover along environmental indices and use these outputs to identify discrete ecoregions within large marine ecosystems. We evaluate the relative importance of predictor variables and apply clustering methods to define important regional boundaries. Multi-species management of marine fisheries resources requires robust methods to synthesize physical and biological data to identify regional structure within large marine ecosystems and to determine the relative impacts of various environmental and biological drivers. By integrating physical and biological data, we partition ecosystems along ecologically significant indices, which can serve as the basis for defining spatial management units applicable to ecosystem based management. We demonstrate this approach by identifying species distributions and delineating distinct ecoregions in the eastern Bering Sea. We also demonstrate the effects of dynamic physical drivers that shift habitat gradients and evaluate the influence of dynamic physical forcing mechanisms on the stability of ecoregion boundaries.

Long-term retention of internal elastomer tags in a wild population of north Pacific giant octopus (*Enteroctopus dofleini*)

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Visible Implant Elastomer (VIE) tags represent a viable approach for long-term tracking of North Pacific giant octopus (*Enteroctopus dofleini*) in Alaska. Over a three year period, we tagged 1,715 E. dofleini with individually identifiable VIE tags and recaptured 242 *E. dofleini* in a 25 km^2 area. Each of the recaptured octopus had tags that were easily identifiable, caused little to no damage to individual octopus and showed a longevity that was previously unobserved in this species. Application of this tagging methodology may have significant merits for ecologists and fisheries managers to understand octopus populations worldwide.

Bering Sea - Fish and Fish Habitat

Electronic field measures of fish body composition, health status and condition – a new development

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We present a newly developed fish specific bioelectrical impedance analyzer that was developed by the North Pacific Research Board (NPRB), the Alaska Fisheries Science Center (AFSC), and RJL Systems. Bioelectrical impedance analysis (BIA) in fisheries research enables efficient, cost effective and accurate measures of body composition, of individual fish in the field in about the same time as standard length weight measurements. BIA provides scientists with increased sample sizes and real-time data and therefore a means for systematic sampling of fish condition that can be incorporated into stock assessments. Previous BIA units were unsuited for fisheries research and needed to be retrofitted for use on fish. Different retrofits resulted in many different methods, protocols and results. What was clearly needed was a standardized fish specific unit. In 2010/2011, the North Pacific Research Board (NPRB) provided funding to develop an automated fish specific BIA board capable of electronic recording automated measures of GPS location, length, weight (motion compensated), resistance, reactance, distance between electrodes and core temperature of the fish. A prototype was used on juvenile salmon surveyed by the AFSC in the Northern Bering Sea Research Area (NBSRA) pelagic ecosystem and was used to determine how energetic allocations are influencing size dependent mortality within stock structures of fish. BIA was used onboard to predict energy content and condition of fish thus allowing a much larger sample size than laboratory analysis alone would allow. Correlations between predicted and observed energy contents were strong (r2=0.94) demonstrating the utility of the device.

Variability in energetic status, diet, and size of age 0 Pacific cod during warm and cold climate states in the eastern Bering Sea

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The revised Oscillating Control Hypothesis for the Bering Sea links groundfish recruitment to climatic processes affecting seasonal sea ice. The hypothesis proposes that these processes drive the quality and quantity of prey available to young fish for growth and energy storage during their critical life history stages. We test this notion for age 0 Pacific cod (*Gadus macrocephalus*) by examining the variability in size, diet, and energy content during warm (2003 to 2005) and cold (2006 to 2011) climate states in the eastern Bering Sea. Initial results suggest that P. cod consumed proportionately more age 0 walleye pollock (*Theragra chalcogramma*) by wet weight during years with warm sea temperatures while consuming proportionately more euphausiids and large copepods during years with cold sea temperatures. An increase in the energy density of P. cod coincided with the diet shift from pollock to euphausiids and copepods. Age 0 P. cod were larger during years with warm sea temperatures; however, there was little variation in their spatial distribution on the shelf among years. The initial results for size, diet, and energetic content of age 0 P. cod are consistent with previously reported data for walleye pollock. The energetic status of P. cod will be related to overwinter survival to determine if cod recruitment is as sensitive to climate conditions as is pollock.

Food consumption of some groundfish species in the Bering Sea

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Commercially important groundfish in the Bering Sea require an intact and productive food web for them to sustain valuable fisheries. Groundfish prey, such as king, Tanner and snow crabs, are also commercially important, but generally remain at low levels due to historical fishing practices and changes to the marine environment. As a result, the groundfish prey base may have changed over time, leading to changes in system productivity that could affect the sustainability of future fisheries. The purpose of this project was to examine trends in prey consumption of different commercially important groundfish species (*Atheresthes stomias*, *Hippoglossus stenolepis*, *Limanda aspera* and *Lepidopsetta polyxystra*) among years, capture depths, substrate type and sampling locations. The National Marine Fisheries Service collected the groundfish stomachs from 1984 to 2010. Stomach samples were identified to the lowest taxonomic level and placed into different prey groups for statistical analysis. General linear models were constructed to determine which variables were significant in predicting prey consumption of groundfish and multivariate regression analysis was used to examine the variability in prey consumption among the four variables examined. All variables were found to be significant in predicting changes in the percent weight and percent frequency of occurrence of prey items found in the stomachs of the four groundfish. The variety of prey shows that groundfish are opportunistic feeders, including a variety of fish, small invertebrates and crabs. Differences in prey consumption among years may reflect differences in predator and prey abundances and intensity of commercial fishing.

Fishery Management strategy evaluations within the Bering Sea ecosystem: contrasted with other case studies

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As part of NPRB funded research to study long and medium term fishery management activities under climate change scenarios, present management strategies are evaluated within a model designed to key physical and biological properties of the Bering Sea. Additionally, alternative fishery management approaches based on simpler multispecies models have been developed for testing. These alternatives represent new sets of harvest control rules and broaden objectives that can be considered by stakeholders. This setting is contrasted with recently adopted management procedures in other parts of the world.

Preliminary age validation of Pacific cod using stable oxygen isotopes (δ18O)

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Pacific cod (*Gadus macrocephalus*) is the second most important groundfish managed by the North Pacific Fishery Management Council, with harvests totaling more than 250,000 mt annually and recent ex-vessel values exceeding $250 million. Pacific cod stock assessments rely on accurate age data to help estimate mortality, recruitment, and allowable harvest. However, Pacific cod age determination has historically been difficult, so uncertainty may exist in allowable biological catches. Our goal was to estimate Pacific cod ageing inaccuracy using stable oxygen isotope (δ18O) signatures in otoliths. This approach is based upon the well-established principle that variability in marine carbonate δ18O is inversely related to water temperature. Therefore, the δ18O signature in an otolith, determined with high-resolution microsampling and mass spectrometry, mirrors annual seasonal temperature cycles, and can be used as a tool for age validation. We sequentially sampled otoliths from specimens estimated to be 2 to 5 years old according to annual growth zone counts. High-resolution micromilling provided up to ten samples (data points) per posited annual growth zone, approaching 50 sequential samples per specimen in some cases. We then analyzed the δ18O of each sample. The δ18O signatures revealed annual seasonal information for age validation and life history information such as possible migrations. The most recently deposited material at the edges of juvenile otoliths (n=10) was also analyzed and related this to a broad range of bottom temperatures measured at capture. We thereby demonstrated the strength of the relationship between δ18O in otoliths and water temperature (r2 = 0.74).

Seasonal distribution and relative abundance of Steller Sea lion groundfish prey in the Aleutian Islands

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Groundfish stocks in Alaska are managed at large scales, however important ecological interactions, such as predation, spawning and habitat selection occur on local scales. Furthermore, commercial fishing is an activity with potential for localized effects. Improved understanding of the local abundance of fish is critical to understanding the potential for localized depletion by fishing. In 1997, the western stock of the Steller sea lion population has been declared endangered. One of the hypotheses for this decline was competition between the commercial groundfish fishery and Steller sea lions for prey. In order to understand the effects of fishing on a local scale, we need to assess abundance and distribution of the prey fields in local areas. This study assesses Steller sea lion prey distribution around rookeries and haulouts in the central Aleutian Islands in the summer and winter. Catch per unit effort indices during a NMFS chartered research cruise are used to examine small scale patterns in Steller sea lion prey distribution. Distribution patterns are related to environmental variables such as depth, temperature and season in three local areas in the central Aleutian Islands: Petrel bank, Tanaga Island and Seguam Pass. The results of this study contribute to an improved understanding of the importance of predator prey interactions between sea lions and groundfish.

Bering Sea - Fish and Fish Habitat

Energy allocation in juvenile salmon: adaptive strategies for overwinter survival

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The importance of energy storage to overwinter survival of salmon can be evaluated by the selective pressure on energy allocation strategies in juvenile salmon. Simple linear models of weight and energy density (Calories/gram) are used to describe species and regional differences in energy allocation of juvenile salmon. These models indicate that energy density increases significantly with weight in all species of juvenile salmon; however, energy accumulation rates are higher in planktivorous species (pink and chum salmon), than piscivorous species (coho and Chinook). Species level differences in energy allocation patterns are believed to reflect different overwinter strategies associated with the different foraging behaviors of juvenile salmon. Similar contrasts between juvenile species are present in the Gulf of Alaska and Bering Sea; however, energy density increases at a lower rate in the Gulf of Alaska. This regional difference is believed to reflect counter gradient variation in juvenile life-history, where higher latitude populations allocate more energy to storage due to higher energy demands required for overwinter survival.

Proxy estimators for FMSY and BMSY for BSAI crab

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Management of Bering Sea and Aleutian Islands (BSAI) crab stocks involves setting an Overfishing Level based on a Maximum Sustainable Yield (MSY) harvest control rule. However, there is insufficient information to estimate the fishing mortality rate and biomass corresponding to MSY (FMSY and BMSY) for any BSAI crab stock. Consequently, proxy values are used for FMSY and BMSY when providing scientific management advice. A variety of approaches for estimating proxy values for FMSY and BMSY have been proposed, but most have not been evaluated formally. We contrast the performances of approaches based on fitting production functions to empirical measures of surplus production and those which apply simplified size-structured models. Simulations tailored to Eastern Bering Sea snow crab and Bristol Bay red king crab show that estimating FMSY and BMSY using production models performs poorly owing to transient dynamical effects. In contrast, simplified size-structured models can be applied to data for most of the BSAI crab stocks, and stock-recruitment relationships fitted under the assumption that FMSY equals the finishing mortality rate at which mature male-biomass-per-recruit is 35% of its unfished level appears reasonable for most stocks. Use of such fitted stock-recruitment relationships is a pragmatic way to provide advice in the types of data-poor situations characteristic of BSAI crab.

An individual-based model for growth of walleye pollock (*Theragra chalcogramma*) in the eastern Bering Sea: implications for bottom-up control of recruitment success

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Understanding the mechanisms behind variability in early life survival of marine fishes will improve predictive capabilities for the recruitment success of commercial species under climate change. Modeling larval ecology that combines information on biotic and abiotic factors affecting survival, such as prey availability and environmental conditions, can improve our understanding of the mechanisms affecting recruitment variability. 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) pelagic ecosystem. Alternating climate states influence the growth, condition, and ultimate survival of walleye pollock through bottom-up control of zooplankton communities. We used an individual-based model (IBM) to better understand the factors affecting growth potential of age-0 walleye pollock in the EBS. The IBM includes a mechanistic prey selection component dependent on larval development and behavior, prey densities and size, as well as light and physical oceanographic conditions such as temperature and turbulence. We applied the model to the EBS in late summer 2010 and included high-resolution field data for prey abundance and condition (i.e., % lipid). We compare model results to estimated growth from a static bioenergetics approach and show areas of predicted increased growth for walleye pollock in the EBS. We discuss the influence of differential prey availability and quality on walleye pollock growth with implications for bottom-up control of recruitment success. Our results emphasize climate-driven effects on recruitment variability in marine fishes and provide an understanding of how ecosystems may respond to shifts in environmental conditions.

Monitoring anadromous lampreys in Alaska: existing and novel approaches

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Lampreys are increasingly recognized as important in both freshwater and marine ecosystems, but initiating formal monitoring is difficult and expensive. However records of marine–phase lamprey are captured in several existing surveys including National Marine Fisheries Service (NMFS) observer reports, NMFS Ecosystem Monitoring Assessment (EMA), and NMFS groundfish surveys. These datasets were examined for spatial and temporal patterns to discern trends in abundance and distribution of two marine-phase lampreys (Lethenteron camtshaticum and Entosphenus tridentatus) found in Alaskan waters. Biennial gaps of trawl survey coverage exist along the Bering slope, a region where E. tridentatus is abundant, so lamprey attack rates on Pacific cod (Gadus macrocephalus) were examined to be used as a proxy for lamprey distribution and abundance in this region. Both actual lamprey catches and attack rates identify regions of lamprey concentration in the ocean, temporal trends in abundance, and size structure of the sampled population. The addition of scanning for attacked fish is a manageable addition to already occurring surveys that can fill data poor regions and years. These results set the stage for a simple "add-on" lamprey monitoring program that focuses on the marine-phase of two anadromous species in Alaska and provides managers with useful baseline information by which goal successes can be measured.

Bering Sea - Fish and Fish Habitat

Warm conditions in the eastern Bering Sea increase pollock cannibalism: a study using multispecies biomass-dynamics models

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Walleye pollock is the most abundant and commercially valuable groundfish species in the eastern Bering Sea (EBS). However, poor recruitment between 2001 and 2005 led to a sharp decline in the EBS pollock stock from 2003 to 2009 and roughly a 40% reduction in catch relative to the previous decade. Juvenile pollock are important forage fish in the EBS ecosystem, often representing the largest fraction in the diets of major Bering Sea piscivores, including arrowtooth flounder, flathead sole, Pacific cod, and adult walleye pollock. Predation on juvenile pollock seems to play an important role in determining pollock recruitment strength. In particular, cannibalism by adult pollock is considered to be a significant source of mortality of juvenile pollock in the EBS ecosystem, causing as much as 40% of juvenile pollock mortality. Some studies have suggested that a pool of cold water on the EBS shelf from seasonal sea ice melt provides a thermal refuge for juvenile pollock from their predators, and that the recent warming trend may have caused an increase in predation on juvenile pollock. We constructed biomass dynamics models of walleye pollock, Pacific cod, arrowtooth flounder, and four other flatfish species with trophic interactions among them to quantify the magnitude of predation. Several models representing alternative hypotheses about the effect of water temperature on predation intensity on juvenile pollock were constructed. Using model selection criterion, we tested a hypothesis that reduction in the extent of the cold pool (indicated by annual mean water temperature) intensified predation on juvenile pollock, contributing to poor pollock recruitment in 2001 through 2005. Preliminary results indicate that an increase in water temperature caused more intense cannibalism on juvenile pollock, while having minor effects on predation of pollock by other fish predators. Despite an increased rate of cannibalism, juvenile mortality owing to cannibalism was low between 2001 and 2005, because of concurrent declines in adult pollock biomass. Therefore, climate likely affected pollock recruitment through processes other than predation, such as reduced forage quality for juvenile pollock under warmer climate conditions.

Interannual variability of dispersal pathways in slope-spawning flatfish in the eastern Bering Sea

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Adult spawning and juvenile settlement locations of marine fishes are often geographically separated. As a result, their early life history stages must rely on transport and retention features, as well as their own behavior, to move them toward or keep them within appropriate juvenile habitats. However, changes in ocean circulation patterns can potentially affect the ability of marine organisms to take advantage of certain circulation features, which can lead to substantial losses of eggs and larvae if offspring are transported beyond typical habitat boundaries. To understand how changes in circulation may influence recruitment and population dynamics in Greenland halibut (GH, *Reinhardtius hippoglossoides*) and Pacific halibut (PH, *Hippoglossus stenolepis*), two commercially-important flatfish species in the eastern Bering Sea (EBS), we reconstructed their dispersal pathways from their source (e.g., spawning areas over the continental slope) to sink locations (e.g., juvenile settling locations over the continental shelf). Annual patterns of dispersal of GH and PH eggs and larvae were simulated from 1982-2004 using DisMELS (Dispersal Model for Early Life Stages), with eggs released on Jan.1st at two spawning locations in Bering Canyon. For sensitivity analysis in relation to spawning time and location, eggs were released in four-day intervals for the duration of the peak spawning season (Nov.2nd - Feb.26th) at 32 presumed spawning locations in two years (1996 and 1997). Location and timing of shelf-break crossings for both species are summarized and results are related to modeled and field estimates of ocean circulation (e.g., drifter trajectories), as well as GH and PH larval and juvenile spatial distributions to explain interannual variability in dispersal corridors. Preliminary results reveal spatial and temporal differences in the dispersal characteristics of the two species, with PH larvae transitioning to the shelf earlier at more southern locations, and GH larvae transitioning to the shelf later at more northern locales. Strong interannual variability in shelf-break crossing location was also observed for both species.

Condition of young Bering Sea Chinook salmon, fall 2010 to winter 2012

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Some populations of Western Alaska Chinook salmon spend their entire ocean life in the Bering Sea and have high fat (lipid) content. 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. Our goal is to identify physical and physiological factors that affect winter survival of young Chinook salmon in the Bering Sea. We present results from field sampling of Chinook bycatch from southeastern Bering Sea trawl fisheries from fall 2010 to winter 2012. Chinook entering the Bering Sea in 2009 had grown to 1.52 kg by fall 2010, 1.85 kg by February 2011, and 3.46 kg in February 2012. Their energy content increased from 1,634 cal/g wet weight to 1,805, to 2,076 over the same period. Lipid content as measured by a fatmeter went from 3.5% to 6.7% to 12.5%. Fish entering the ocean in 2010 weighed 0.3 kg in February 2011 and had grown to 1.93 kg by the February 2012. Energy and lipid content increased from 1,432 cal/g wet weight and 2.8% to 1,942 cal and 8.3% in one year. Moisture content, caloric values, and fatmeter measurements were closely correlated with each other and with the size of fish; fatmeter readings often showed the closest correlations with caloric values. Condition factor (weight/length3) had a weaker relation to energy density. Diets were primarily gonatid squid and osmerid fish, but proportions varied greatly between years, and not consistently with season. Fish of different ages and sizes generally consumed the same prey types. Fewer stomachs were empty in fall than in winter, and those with food in fall were fuller, on average. Prey length showed only very weak positive relationships to Chinook length. Isotope data and results of bioenergetic modeling will also be presented.

Bering Sea - Seabirds

Nesting habitat availability on a catastrophically disturbed island: Response of crested and least auklet populations

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Prior to its' eruption in August 2008, Kasatochi Island was a major crested auklet (*Aethia cristatella*) and least auklet (*Aethia pusilla*) colony site. The eruption buried all existing nesting habitat. However, surveys at sea in 2009 found no significant changes in auklet densities, indicating that most adults had survived. Despite extensive erosion nearly all of the pre-eruption nesting habitat for auklets remains covered with ash and bird nesting attempts have been restricted to low quality habitats near beaches. Although offshore (1.6-2 km) densities of auklets have not changed over time, nearshore surveys (300 m) suggest that populations of both crested and least auklets using the island have declined. In 2011 large numbers of auklets were observed using a rockfall area in a watershed north of the primary colony site. Repeated photographs of this cove illustrate the accumulation of large rocks and talus. Large numbers of birds were first seen using the area in June of 2011. We were able to gain access to this new area through an erosion gully in June of 2012 and were able to confirm that this new colony site was being used for nesting by thousands of birds. Despite the substantial erosion, the only high quality nesting habitat currently available to crested and least auklets is the new rockfall site. Our results indicate that in the case of crevice nesting species, the creation of new nesting habitat can be a relatively quick process and may be predictable based on the geomorphology of the environment.

Bering Sea - Seabirds

Mercury concentrations in tissues of birds at Agattu Island, Aleutian Archipelago, Alaska

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Mercury (Hg) is a toxic element that is transported atmospherically, distributed globally, and can negatively influence avian populations. Agattu Island, located in the western Aleutian Archipelago, Alaska, is a remote island that does not have a history of anthropogenic Hg contamination. Using samples collected at Agattu Island from 2005-2006 and 2008-2011, we analyzed total mercury (THg) concentrations of feathers and eggshells of four bird species. Total Hg concentrations were relatively consistent between years for all species. Breast feathers of Fork-tailed Storm-petrels (*Oceanodroma furcata*) had the highest THg concentrations. Total Hg concentrations of egg shells and body feathers of adult and nestling Kittlitz's Murrelets (*Brachyramphus brevirostris*) were relatively high compared to similar species and were comparable to concentrations in feathers of Snowy Owls (*Bubo scandiacus*), a top marine predator in the Aleutian Islands. As predicted by feeding guild, Evermann's Rock Ptarmigan (*Lagopus muta evermanni*) feathers had the lowest THg concentrations. Overall, avian tissues analyzed from Agattu had greater THg concentrations than would be expected for a remote location with no point-source Hg pollution.

Diet of a snowy owl population from the Western Aleutian Archipelago, Alaska

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The Snowy Owl (*Bubo scandiacus*) is a circumpolar species with a diet composed mostly of small mammals. At Agattu Island, an island lacking terrestrial mammals, in the Aleutian Archipelago, Alaska, Snowy Owls subsist entirely on a diet of birds. We analyzed the contents of 104 Snowy Owl pellets collected at Agattu Island during May-August 2008. We document the importance of seabirds in the diet of Snowy Owls at Agattu Island, which is home to over 40,000 breeding seabirds. Storm-petrels (*Oceanodroma* spp.) were the most frequent prey item (61%), and contributed 18% of overall biomass. Ancient Murrelets (*Synthliboramphus antiquus*) were found in 20% of pellets and accounted for 23% of the overall biomass. Large prey such as the Aleutian Cackling Goose (*Branta hutchinsii leucopareia*) and Mallard (*Anas platyrhynchos*) were infrequent in pellet remains (1% and 2%, respectively), but contributed substantially to overall biomass (7% and 13%, respectively). Snowy Owl observations were rare, but an adult was observed on six separate occasions during June-August and on one occasion, two individuals were seen together. In addition to pellet diet analysis, we documented a Snowy Owl depredation of a Kittlitz's Murrelet (*Brachyramphus brevirostris*) chick at the nest. Snowy Owls, where they occur, likely exploit seabirds as a prey resource throughout the archipelago.

Bering Sea - Seabirds

Distribution of subadult short-tailed albatross in the Bering Sea

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In the Bering Sea, the distribution of endangered short-tailed albatross (STAL), *Phoebastria albatrus*, overlaps extensively with commercial fisheries. STAL spend much of their non-breeding period foraging along the Bering Sea outer continental shelf and break-slope habitat, a region also used extensively by commercial longline fleets. These common grounds between Alaskan commercial fisheries and STAL have resulted in incidental mortalities. Of these documented STAL mortalities, eight of ten have occurred during the fall season in the Bering Sea, most in the Pacific cod (*Gadus macrocephalus*) longline fishery, and 80% were juveniles (1yr) or subadults (2-3 yrs). Three have occurred in past two years.

The Bering Sea shelf break is bisected by numerous submarine canyons, among the largest in the world, that are extensively used by STAL. We investigated variability in subadult STAL distribution in the Bering Sea among seasons, sexes, age classes, and source colonies. Albatrosses were tracked between 2008 and 2012, and included a total of 44 birds, 13 of which were tracked over multiple years. STAL use of Bering Sea canyons and adjacent shelf habitat are non-uniform. Preliminary findings show birds favoring canyons, specifically Navarin and to a lesser extent Zemchug canyon and adjacent shelf areas. These results will be used to examine theories for bycatch patterns, including whether increased overlap between subadult STAL and the Pacific cod longline fishery occur within albatross high use areas or after trawl fisheries move out of the area. This research will provide needed information on recent foraging distributions of juvenile and subadult STAL, which varies considerably from adults, and assess potential explanations for recent bycatch in Pacific cod longline fisheries.

Bering Sea - Seabirds

Colony differences in foraging ecology of Pribilof thick-billed murres (*Uria lomvia*) during the non-breeding season

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At the Pribilof Island colonies in the southeastern Bering Sea, populations of thick-billed murres on St Paul Island have decreased over the last 30 years, whereas populations at the larger colony on St George Island have remained relatively stable. To understand this dichotomy, it is critical to know whether over-wintering strategies differ between island populations. Here, we studied winter distributions, habitat use, and diet of thick-billed murres from these two geographically close colonies during the winter of 2009-10. We used miniature geolocation loggers to track movements, combined with remote sensing of oceanographic data, and stable isotope analysis of feathers to gain a more complete picture of the winter ecology and trophic placement. All thick-billed murres had a restricted wintering range in the Bering Sea and in areas south of the Aleutian Islands, but showed inter-colony differences in spatial distributions, associated habitat, and diet. Birds from St Paul were more likely to winter in the Bering Sea than their counterparts on St George experiencing cooler sea surface temperatures and foraging over shallower depths. St Paul birds also foraged on average at a higher trophic level both during the fall and late winter as determined by feather stable isotope values. Our results suggest that colony differences in location, habitats, and diets during the non-breeding period may contribute to the observed declines in thick-billed murre populations on St Paul Island.

Bering Sea - Seabirds

Seabirds as indicators of forage fish stocks and marine ecosystems in Alaska

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The distribution and abundance of small, schooling forage fish (e.g., sandlance, capelin) in Alaska is known from small-scale directed studies, but mostly inferred from incidental catches in large-scale trawl surveys that were not designed (by gear or location) to sample forage species. In contrast, seabirds are conspicuous, highly mobile, samplers of forage fish that go to great distances (100+ km) and depths (≤ 200m) to locate ephemeral prey with great efficiency. Thus, data on their dietary habits provides a valuable complement to traditional fisheries sampling. We have begun to analyze diet databases for several common Alaskan seabirds (puffins, murres and kittiwakes). Our goals are to characterize forage fish communities in the Gulf of Alaska and Bering Sea/Aleutians, describe temporal changes in abundance of forage species in relation to marine climate, and examine the possibility of using diet data to assess recruitment in selected commercial fish species. Most of our work to date has focused on compiling datasets. We will discuss the nature of these datasets, and present some preliminary findings.

Three-dimensional spatial use of marine habitats provides insight into the contrasting population trends of thick-billed murres (*Uria lomvia*) at the Pribilof Islands

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Although the thick-billed murre (*Uria lomvia*), a deep-diving seabird, is known to have remarkable flexibility in foraging behavior that buffers reproductive success, long-term population trends on the two Pribilof islands, St. Paul (declining) and St. George (stable), have different trajectories. Our study combines foraging location, diving behavior, diets and estimates of chick-feeding frequency and fledging success to examine whether birds nesting at these two neighboring continental shelf-based islands differ in foraging effort during chick rearing. During the three study years (2008-2010), birds from St. Paul Island, located further from the continental slope, foraged entirely on the shelf, while those from St. George foraged both on the shelf and slope. On the shelf, birds from St. Paul made longer trips than those at St. George regardless of time of day (day and night), and trips to the slope by St. George murres overnight were the longest. Birds from both colonies dived deeper during the day, intermediate at twilight and shallower at night across years. Colony differences in dive depth were only found during daytime; birds from St. George dived deeper in 2008, and birds from St. Paul dive deeper in 2010. The lower diving activity recorded at night over the shelf suggests that St. Paul murres had limited temporal access to abundant and high-quality prey compared to St. George murres that were able to exploit oceanic rich-lipid prey at night. Birds from both islands feed and fledged chicks at similar rates and delivered equivalent quality prey, mainly fish species and inshore squid. Adults from St. Paul fed with lower quality prey (age-0 pollock) than St. George murres (pelagic squid). Altogether our results indicate that different foraging strategies maybe facultative of colony location, and as a result birds from St. Paul may have lower energy gain than their counterparts at St. George with potential effects on adult survival.

Bering Sea - Seabirds

Predation on seabirds by Pacific cod (*Gadus macrocephalus*) near the Aleutian Islands: an emerging phenomenon?

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In marine systems, most seabirds are considered top-level predators, yet may be vulnerable to predation by other marine animals. Despite varying accounts of large fish eating birds, little is known about whether predation by demersal fish predators is an important source of mortality for seabirds. Fish processors in Dutch Harbor, Alaska, have recently observed presence of seabird remains in Pacific cod (*Gadus macrocephalus*) stomachs. We studied seabird remains from pacific cod (likely 6-7 pounds) caught off Cape Sarichef in Unimak Pass from mid-January through early April 2011 by trawl and pot gear. There were 74 different seabird remains, and a proportion of these were identified to species (N=59) or genus (N=15). There were four avian species identified in the remains; crested auklet (*Aethia cristatella*, N=55), Cassin's auklet (*Ptychoramphus aleuticus*, N=1), common murre (*Uria aalge*, N=2), and thick-billed murre (*Uris lomvia*, N=1). Additionally, there were remains identified to genus; *Aethia* sp (N=13), *Uria* sp. (N=1), and *Larus* sp (N=1). These results provide documentation that Pacific cod consume seabirds; either by predation or scavenging. Pacific cod may take advantage of large concentrations of seabirds wintering in open waters, potentially making this a seasonal and spatial occurrence. Is this a newly recorded predator-prey relationship, and an emerging phenomenon in the Bering Sea?

Bering Sea - Mammals

The LIMPET tag as an alternative method for satellite tagging beluga whales

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Satellite-linked location tags provide valuable data for determining habitat use and movement patterns of marine mammals. The current state-of-the-art method for attaching satellite tags to beluga whales involves capturing a whale, moving it into shallow water, and holding it while the tag is attached. This process ensures a secure attachment of the tag that can last for up to a year or more, but the capture and handling process subjects belugas to stress and includes some risk of mortality. Therefore, we set out to test a recently developed satellite tag and attachment system that can be remotely-applied to beluga whales without the need for capture. This system utilizes a crossbow or pressurized air to project the Low Impact Minimally-Percutaneous External-Electronics Transmitter (LIMPET) tag, which includes two small barbed titanium darts (0.6 cm diameter) that penetrate up to 7 cm into tissue, preferably the dorsal fin. From 8 to 12 September 2012 we deployed five LIMPET location-only satellite tags on belugas that were captured in Bristol Bay for a health-assessment and movement study (marine mammal research permit # 14245). By attaching the tags to captured belugas, we were able to ensure that the tags were applied to the most appropriate part of the body (the dorsal ridge) and eliminated any variability in depth of penetration of the darts. As of 27 September 2012, all five tags were still transmitting, 15 – 19 days after deployment. Given the absence of a dorsal fin and the rubbing behavior of belugas, this is a surprisingly good result. Based on this preliminary retention duration, we suggest that LIMPET tags might be a good choice in situations when tracking durations of a few weeks would be valuable but capture is not feasible, or for situations that require rapid deployment of tags, such as in the case of a multiple live-stranding so that the fate of refloated belugas can be monitored.

Bering Sea - Mammals

Foraging a new trail with northern fur seals (*Callorhinus ursinus*): Ecological insights from fine scale spatial and behavioral analyses with a new biologger

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The intermittent collection of GPS locations by electronic tracking tags likely obscures detection of finer scale processes that are important for understanding the foraging ecology of marine mammals. We compared two methods for reconstructing the foraging tracks of lactating northern fur seals (Callorhinus ursinus) from two eastern Bering Sea islands (St. Paul Island and Bogoslof Island) using location data at two different scales. The first method joined the at-sea GPS locations collected at a maximum of 4-times per hour, and the second method used triaxial accelerometer and magnetometer data collected 16 times per second (16 Hz) to interpolate movements between GPS fixes. The detailed movement data revealed differences in foraging behavior between and within islands that were not detected using the GPS interpolated dive data alone. Total distances traveled per trip averaged 1053 km for St. Paul and 428 km for Bogoslof fur seals, which was 1.5 and 2.0 times further than distances calculated using linearly interpolated GPS tracks. First-passage-time metrics (a measure of foraging activity) from the higher-resolution data indicated that fur seals from St. Paul that travelled to the Bering Sea basin foraged at a scale that was an order of magnitude greater than Bogoslof fur seals (similarly feeding in the Bering Sea basin) or other St. Paul fur seals (feeding over the shelf). However, these scales remained 1–2 orders of magnitude smaller than indicated by GPS data. Overall, analyses of location data collected at 1Hz and higher significantly changed quantitative measures of foraging trip metrics, resulting in a qualitative reinterpretation of the summer foraging ecology of lactating northern fur seals. In addition, behavioral analysis from the accelerometer data also revealed 5 distinct behaviors (diving, resting, grooming and two types of spinning). Statistical analyses indicated that the percentage of time spent in each of the 5 differentiable behaviors was significantly different between islands, foraging habitat (on-shelf or off-shelf), and total trip length.

Associations between North Pacific right whales and their zooplanktonic prey in the southeastern Bering Sea

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Because of the seriously endangered status of North Pacific right whales (*Eubalaena japonica*), an improved understanding of the environmental factors that influence the species' distribution and occurrence is needed to better assess the effects of climate change and industrial activities on the population. Associations among right whales, zooplankton, and the physical environment were examined in the middle shelf domain of the southeastern Bering Sea during the summers of 2008 and 2009. Sampling with nets, an optical plankton counter, and a video plankton recorder in proximity to whales as well as along cross-isobath surveys indicated that *Calanus marshallae* is the primary prey of right whales in this region. Acoustic detections of right whales from sonobuoys were strongly associated with *C. marshallae* abundance, and peak abundance estimates of *C. marshallae* in 2.5 m depth strata near right whales ranged as high as 1,000,000 copepods per cubic meter. The smaller *Pseudocalanus* spp. were as numerically abundant as *C. marshallae*, suggesting that these copepods could possibly serve as a secondary food resource for right whales. High concentrations of *C. marshallae* occurred in both the surface and bottom layers of the highly stratified water column, but there was no evidence of diel vertical migration. Instead, occurrence of *C. marshallae* in the bottom layer was associated with elevated near-bottom light attenuance and chlorophyll fluorescence, suggesting *C. marshallae* may feed on resuspended phytodetritus at depth. The middle shelf domain likely attracts right whales because of the high abundance of *C. marshallae* there, but it remains unclear what processes aggregate *C. marshallae* into concentrated patches upon which the whales feed. Despite the occasional presence of strong gradients in hydrographic properties, no association was found between *C. marshallae* and either fronts or phytoplankton distribution. We hypothesize that tidal currents resuspend patches of phytodetritus in the relatively slow-moving bottom waters, and that vertically swimming *C. marshallae* from the faster flowing surface waters discover and feed within these patches. This process aggregates copepods both horizontally and vertically, and ultimately attracts right whales to the middle shelf domain.

Bering Sea - Mammals

Killer whale (*Orcinus orca*) depredation on the Greenland halibut (*Reinhardtius hippoglossoides*) long-line fishery in the Sea of Okhotsk

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Fishermen faced the problem of killer whales (KW) depredation on long-line fisheries about 60 years ago. Specialists and fishermen from different countries have tried to resolve this problem for many years, but no effective solution has been found. The goal of the current study was to determine the impact of KW on the long-line fisheries of Greenland halibut (GH, *Reinhardtius hippoglossoides*) in the Sea of Okhotsk. Observations of the appearance and activity of KW were conducted daily during the daylight hours from the deck or bridge of the bottom hook long-line fishing vessel (51.21 m long and 9.2 m wide, tonnage 1190) between February 29 and April 14, 2012. From540 hours of observation, KW were present near vessel for 65 hours (12%). A total of 88 lines consisting of 8-12 segments (ave=8.7±1.1) that ranged in length from 10,080m to 15,120m (ave=10934±1385m) were soaked and hauled. The lines were soaked at an average depth of 569±57m. During the study period that included setting 828,450 hooks, a total of 21,414 GH were caught (≈ 33,000 kg). KW approached the fishing vessel during 10 days. On days without KW the average catch per line was 248±155 halibuts (378±238 kg). When KW were present, the average catch per line was significantly ($p<0.001$) lower (48±155ps). From all soaked lines KW ate fish from 18 lines (20.4%). Depredation occurred only during gear hauling. Overall, during the study period KW consumed about 5000 ps. of GH (8,000 kg; ≈ 20% of total catch). The number of KW in a group fluctuated from 1 to 10 individuals. A single KW, which was observed once, ate about 150 ps. (≈250-300kg) of GH (about 5-6% of its total body weight). KW more often approached the boat ($Z=-4.3$, $p<0.0001$, $n=38$) when the weather was good (≈ 0-4 ball), compared to when the weather was stormy (>4 ball). Fishermen also confirmed that KW never consumed fish from long-lines during stormy weather. This feature of KW behavior can be the key factor in finding a solution to reduce KW depredation.

Bering Sea - Mammals

Changes in the timing of seasonal movements of Steller sea lions in the Commander Islands, Russia

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Steller sea lions (SSL) were monitored daily during summer and fall on the Severo-Zapadny Cape (SZ) haulout on Bering Island, Commander Islands (CI), in 2010 and 2012. Composite counts and recordings of presence of marked animals were performed several times during daylight hours every day (add start to end dates here). Numbers of SSL hauled-out at SZ increased steadily during June in both years with similar rates, reaching about 60-70 non-pups in early July. In the second week of July 2010 the number of SSL sharply increased up to 113 and then went down to 80 individuals by July 31, while in 2012 the number was fluctuating between 60 to 80 individuals only. From August until 10 September 2010 the total numbers of SSL slowly decreased to 40 animals in both years, but after that date another sharp increase up to 100 individuals occurred in 2010, while in 2012 the numbers stayed around 40 animals. Brand resight data allowed us to conclude that different groups of migrating SSL were involved in both spikes in abundance of SSL on the SZ haulout in 2010. More remarkable differences were found in the movement of lactating SSL females. Pup branding occurred on the southern end of Medny Island in early July in both years. In 2010 the first branded pup with its mother appeared on the SZ haulout 10 days after branding while in 2012 it didn't occur until September 10th. A sharp wave of arrival of branded pups with their mothers from Medny I. was recorded between September 16 - 26 in 2010 (up to 36 pups) while in 2012 only 10 branded pups visited the SZ haulout by the end of September. Therefore, there was a much lower rate of seasonal migrating activity of SSL in the summer and early fall in the CI in 2012 compared with 2010. Large interannual differences in migratory patterns of CI SSL may be an important factor in their unstable population trends.

Bering-Okhotsk Seal Surveys (BOSS): Joint US-Russian Aerial Surveys for Ice-Associated Seals, April – May 2012

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A survey for the abundance and distribution of four species of ice-associated seals (bearded, spotted, ribbon, and ringed seals) was conducted in the Bering Sea from 1 April to 23 May 2012. US survey flights originated from airports in Nome, Bethel, and Dillingham, AK and utilized airstrips in Gambell, on St. Lawrence Island, and St. Paul, in the Pribilof Islands, to reach the most remote areas of sea ice in the central Bering Sea. The Russian team began western Bering Sea surveys in mid-April from Ossora, Russia, on the Kamchatka Peninsula and worked their way north to the Bering Strait. Most US flights were at an altitude of 1,000 ft (300 m). A NOAA Twin Otter carried three FLIR SC645 thermal imagers that recorded continuous data in the 7.5-13.0 μm wavelength. Each thermal imager was paired with a digital single-lens reflex (SLR) camera with a 100-mm lens. The combined thermal swath width was approximately 1,500 ft (470 m). A second US aircraft (Aero Commander) carried two sets of paired instruments, providing a swath width of approximately 900 ft (280 m). The two US aircraft flew over 14,000 nautical miles (27,000 km) during 39 surveys, and collected more than 885,600 SLR images. The Russian aircraft (AN-38 Vostok) flew over 4,200 nautical miles (7,800 km) during 12 surveys with similar instruments that provided a thermal swath width of approximately 2460 ft (750 m) at an altitude of 820 ft (250 m). The thermal imagers detect the warm bodies of seals against the background of the cold sea ice, and the high-resolution digital images help to identify the seal to species. A second survey, in the spring of 2013, will include the ice-covered areas of the Sea of Okhotsk. Ultimately, the seal counts will be used to produce the first comprehensive estimates of abundance for the four species of ice-associated seals found in the Okhotsk and Bering seas, accounting for multiple sources of uncertainty including detection rates; seal haul-out behavior; species identification; and changes in ice extent and distribution.

First description of beluga whale hearing in the wild

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Beluga whales (*Delphinapterus leucas*) have been identified as Arctic ecosystem sentinels because they are broadly dispersed, high trophic feeders and are likely to be negatively impacted by climate change They are highly dependent on hearing and underwater sound to enact key biological activities such as forage for prey, communicate with conspecifics and navigate. Therefore, understanding how noise might affect their sensory ecology is a priority to encourage their survival and address the broader potential acoustic impacts within the Arctic. Ocean noise levels are increasing in the Arctic due to an increase in human activities, which are related to the interests in Actic resources and the opening of the Northwest Passage. This is of concern because several beluga populations are endangered and considered strategic stocks. Their sound sensitivities are unknown. The work presented here describes for the fisrt time the hearing abilities of wild belugas. Using auditory evoked potential (AEP) methods, detailed audiograms (4-150 kHz) were collected in 7 belugas during a capture-release setting to assess the health status of a subset of the Bristol Bay beluga population. We present here the first population evaluation of hearing in an odontocete species other than bottlenose dolphin (*Tursiops truncatus*). Sensitivites were as low at 45 dB SPL and reponses were found up to 100 kHz in all animals and up to 150 kHz in 2-3 animals. Most had a high frequency cut-off of 128 kHz. These hearing abilities are excellent compared to many other odontocetes, including captive beluga whales. The hearing curves are appraised relative to demographic and health-related meta-data from the animals from which the measurements were made. We define the natural and baseline hearing abilities and variability in these wild belugas, placing the results in the context of potential ecological influences and that of anthropogenic noise.

Movements and habitat selection of Bristol Bay beluga whales

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The Bristol Bay stock of beluga whales (*Delphinapterus leucas*) is one of five stocks recognized in Alaska and, like the Endangered Cook Inlet stock, is associated with estuarine habitats characterized by large tidal fluctuations, extensive mud flats, and large salmon runs. Unlike the Cook Inlet stock, the Bristol Bay stock is increasing. Because both stocks occupy similar systems, information on movements and habitat selection of the Bristol Bay stock may be useful for comparison with the Cook Inlet stock. Between 2002 and 2011, we attached satellite-linked tags to 35 beluga whales. In ice-free seasons, belugas were generally associated with mud flats and were located within 5 km of shore. In April, beluga whales followed retreating ice up the Kvichak, Nushagak, and Snake rivers, likely feeding on spawning rainbow smelt (*Osmerus mordax*). After break-up, belugas ranged widely along the inner coast of Bristol Bay, often traveling between Nushagak and Kvichak bays. When salmon (*Oncorhynchus* spp.) arrived to spawn in mid-June, most belugas either moved to the mouth of the Snake River in Nushagak Bay or to the mouth of the Kvichak River in Kvichak Bay; both areas have extensive mud flats where salmon may concentrate and be easier for belugas to hunt. Few salmon spawn in the Snake River; hence belugas are likely intercepting salmon traveling to the Nushagak and Wood rivers. The probability that belugas selected the Snake or Kvichak river mouths during salmon spawning was only weakly correlated with the number of salmon, as indexed by escapement counts. However, belugas were more likely to switch sites within years when their current site was characterized by below average salmon escapement. Between September and November, after the salmon runs ended, belugas again ranged widely along the inner coast of Bristol Bay. In December and January, belugas moved offshore as sea ice formed in Kvichak and Nushagak bays. Tagged belugas generally passed no farther west than Cape Pierce in the north and Ugashik Bay in the south; hence, we found no evidence suggesting members of this stock of belugas ever leaves Bristol Bay.

Bering Sea - Mammals

Stereotyped, repetitive gunshot call patterns produced by the North Pacific right whale, *Eubalaena japonica*

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Because of their distinct vocalizations, right whales are easily identified and distinguished from other vocalizing marine mammals, making them an ideal species for passive acoustic monitoring. As a result, numerous studies on right whale vocalizations have been conducted. In order to acoustically monitor the critically endangered North Pacific right whale (NPRW), the National Marine Mammal Laboratory has placed long-term passive acoustic recorders throughout the southeastern Bering Sea since 2007. Autonomous Underwater Recorders for Acoustic Listening (AURAL, Multi-Électronique, Quebec), located on the Pacific Marine Environmental Laboratory's oceanographic moorings along the 70m isobath in the Bering Sea, record at a sampling rate of 8 kHz either near-continuously or on a 45% duty cycle. Ecological Acoustic Recorders (EAR, Marc Lammers, Oceanwide Science Institute) have been deployed in various locations throughout the SEBS, sampling at 4 kHz on a (6.7-11%) duty cycle. In addition, during the summer field surveys, DiFAR (Directional Frequency Analysis and Recording) sonobuoys were deployed to monitor for the presence of large whales in real-time. During the 2010 Chukchi Acoustics, Oceanography, and Zooplankton (CHAOZ) study, a stereotyped, repetitive gunshot call pattern was acoustically detected on sonobuoys. The long-term moored passive acoustic recorders detected this same call pattern on two different recorders in two separate years. Further analysis revealed several different stereotyped, repetitive gunshot call patterns. To date, six different patterns have been documented, three of which have been analyzed. Preliminary results show that each pattern has a minimum of 30 iterations repeated over several hours, and in several cases is repeated throughout the season. Furthermore, several of these patterns have been detected not only throughout a season, but also in consecutive years, and in one instance, in non-consecutive years. While male North Atlantic right whales have been observed producing long gunshot bouts similar to the reproductive advertisement known in other species (Parks et al. 2012), right whales were not known to produce any type of repeated stereotyped pattern. This represents the first study to document stereotyped repetitive gunshot patterning in right whales; whether this can be classified as song remains to be determined. [Work supported by Bureau of Ocean Energy Management]

Bering Sea - Mammals

IS Overall Dynamic Body Acceleration (ODBA) a good predictor of the energy expended by northern fur seals while foraging?

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Accurate measures of energy expenditure of northern fur seals at sea are key to understanding their foraging efficiency, and thus their survival and reproduction success. Established techniques to do so either involve invasive procedures or are highly costly for large animals. A new technique called ODBA (Overall Dynamic Body Acceleration) that is based on body acceleration of the animal in tri-dimensional axes has emerged as an easy and cost-effective alternative to measure energy expenditure in birds and sharks—but has never been tested on free-ranging fur seals. Our goal was to determine whether ODBA is an accurate predictor of foraging costs for northern fur seals. To do so, we tested ODBA against the well-established (but expensive) technique of Doubly-Labelled Water (DLW) on 20 females during their breeding season. We equipped them with tridimensional accelerometers (from daily diary tags) and simultaneously injected them with doubly labelled water. Morphometric measurements before and after a foraging trip were also taken, and foraging behaviours and diving parameters were calculated from GPS and Time-Depth-Recorder data. Our findings show how estimates of ODBA can be altered by the data filter chosen to extract dynamic acceleration from total acceleration. Our results also show a counter-intuitive weak negative relationship between ODBA measured over an entire foraging trip and energy expenditure measured by DLW—but no relationships between energy expenditure and ODBA when animal was traveling at the surface or diving, or between night and day. ODBA measured for an entire foraging trip does not appear to provide an accurate measure of energy expenditure. However, ODBA may be useful for estimating the energy expended while engaged in individual behaviours (e.g., grooming, travelling, diving, etc.). Further fine scale testing is warranted.

Bering Sea - Mammals

Remotely delivered chemical immobilization of adult female Steller sea lions (*Eumetopias jubatus*) and post-handling foraging behaviors

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Nutritionally-mediated reductions in fecundity is one hypothesized mechanism for continued declines of Steller sea lion (*Eumetopias jubatus*) in parts of Alaska, but little is known of the winter foraging habitats or behavior of adult females. Understanding foraging behavior 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. To develop safer capture techniques and understand winter foraging behavior of adult female Steller sea lions, we immobilized six with dependent pups in Southeast Alaska (SEAK) during November 2010 (successfully handling three) and four in the central Aleutian Islands (CAI) during November 2011 (successfully handling one) using a novel 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 remote dart delivery. Animals were approached approximately 12 minutes after darting and were supplemented with isoflurane (range 0.5-1.5%) in 100% oxygen to maintain anesthesia for ≤130 minutes. After animals were sampled, branded, and tagged with Mk10 Argos Fast-GPS transmitters, they were reversed with naltrexone (30 mg) and atipamezole (45 mg) via intramuscular injection. Four of six darted animals that entered the water after injection were followed up to 145 min to verify survival, whereas post-handling foraging behaviors were monitored up to eight months for four tagged animals, providing the longest duration of tracking data available for adult females (>200 days). Each animal demonstrated unique foraging patterns, but overall locations and depths of dives of sea lions from SEAK were associated with over-winter locations of herring, followed by dispersion as spawning aggregations of herring, eulachon, and salmon developed. Behaviors of the sea lion from the CAI coupled with species composition bottom trawls suggested she was foraging on a combination of prey species likely associated with habitat features (e.g. bathymetry and tides). Compared with published studies conducted during summer and winter months, winter sea lions used multiple haulout sites and dove to deeper depths more frequently in SEAK. Although previous studies found associations of sea lion abundance with prey availability, this is the first study to illustrate distinct diving behaviors associated with targeted prey species.

Encounters of Steller sea lions in herring and pollock fisheries in the western Bering Sea

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Observations were conducted daily from the upper deck of large trawler factory with a daijy processing capacity of 70-80 metric tons (mt). Total effort time was 245 hours. The ship was involved in pollock fishing from October 23 through November 14, 2011 in Olutorsky and Korfa Gulfs, on average 20-40 miles off shore. The mid-water trawl type DT/TB–BADA 67/96 m long with mesh size 60×60 mm was used. A total of 52 tows (average 2.5 tows/day) were made during this period and 2,186 mt of pollock was caught and processed on board. Steller sea lions (SSL) were not observed in near proximity of the fishing vessel during pollock fishing. Herring fishing was conducted from November 15 through December 7, 2011 in Korfo-Karaginsky Region at a distance of about 15 to 20 miles from the coast line. The mid-water trawl type PT/TM 154/1120 with a mesh size 60×60 mm was used. The total catch of herring was 1,848 mt with an average of 52 mt per tow. A total of 37 tows were made. SSL were not recorded in by-catch during herring fishing, but they were encountered in close proximity to the fishing vessel 12 times. The total number of SSL that were seen was about 70 individuals. Most encounters (75%) occurred in twilight and night time. The number of SSL encounters increased in late November early December and was related probably with increased herring abundance and school density in the fishing area. Seven SSL haul-outs are present in the region, but most have been abandoned during the last 15-20 years in summer. At the same time SSL are regularly encountered in this region from fishing vessels in fall and winter. Perhaps this is due to migration from summer breeding areas to feed on herring aggregations which form near-shore in the region in fall and spring. Areas of SSL foraging on herring aggregations overlap with commercial fisheries. Although we did observe SSL bycatch on the observed vessel, a high level of SSL by-catch in this region was reported in 1970s and 1980s when SSL abundance was much higher.

Steller sea lion (*Eumetopias jubatus*) by-catch in the Western Bering Sea

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The Steller sea lion (SSL) population in the Western Bering Sea (WBS) declined by 99.7% over the last 30 years and has shown no signs of recovery. This area is one of the most important commercial fishery areas in the Northern Pacific. One of the possible reasons for the dramatic decline can attributed to incidental mortality in fishing gear. To test this hypothesis 62 fishermen and scientific observers were interviewed in Petropavlovsk-Kamchatsky (Russia) in 2011-2012. They provided anecdotal information on SSL by-catch for the years 1960 through 2000. Sixty-eight percent (68%) of respondents confirmed that SSL were incidentally caught during their work on fishing vessels. Twenty-six (42%) fishermen remembered what fishery they were working when SSL were caught: 85% was pollock, 12% was herring, and 4% was Atka mackerel fishery. Fifty-two percent of respondents remembered in what type of fishing gear the SSL were caught: 97% in trawls and 3% in snurrevaad. Twenty-seven percent of respondents remembered the time of year and in all cases (100%) SSL were captured in fall-winter. Most of the SSL (71%) were caught by large freezer trawler (BMRT or BATM type) (and in all other cases by middle size fishing vessels (SRTM or ST). Overall, all respondents agreed on several points: the level of by-catch was much higher in the 1970s - 1990s than in the 2000s; the group size of entrapped SSL in a single tow was larger (5-30 vs 1-3 individuals); most by-caught SSL were found dead, only some large adult males were alive; SSL were mostly caught in near-shore areas (where the shore line can be seen from the ship). Collected information doesn't allow us to make any statistical calculations on the total number of SSL that died in fishing gear in the WBS in the analyzed period, but should be considered. Due to the absence of an independent observation system in commercial fisheries in the Russian Far East, fishermen interviews should be continued and extended to the full range of SSL in the Russian Far East.

Bering Sea - Mammals

Is there a relationship between diet and population trend of Steller sea lions in the Aleutian Islands? (NPRB #1114)

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Since 1990, there has been considerable variation in Steller sea lion population trend in the Aleutian Islands, with annual rates of change in counts of pups and non-pups (adults and juveniles) becoming increasingly negative with increasing distance west of 170°W. We will test the hypothesis (H0) that Steller sea lion population trend is unrelated to diet. The alternative hypothesis, H1, posits a direct 'bottom-up' relationship between prey energy density/diet diversity and trend. In March 2012, NMFS and UAF conducted a joint research cruise aboard the RV Norseman in the Aleutian Islands to collect Steller sea lion diet samples (NPRB #1114) and test the use of unmanned aircraft as a sea lion survey tool (NPRB #1120; see Walker et al. abstract). Diet samples were collected in March (345 scats and spews) as well as in June/July 2012 (N=53) and prey species will be identified from hard part (e.g., fish bones and otoliths, cephalopod beaks) remains. In addition, we will conduct DNA analyses of soft material from these samples and an additional 305 collected in April 2008 (NPRB #730) to identify species (e.g., cephalopods, salmon, and skates) that are not well-represented in hard part remains in order to more completely describe the diet of sea lions in the Aleutian Islands. We will examine statistical relationships between diet (> 2,000 samples), fish community structure (from AFSC bottom trawl surveys), and sea lion population trends in the Aleutian Islands for the 1990-2012 period. Preliminary analysis (based on frequency of occurrence of hard parts) indicates that seasonal diets of sea lions in the Aleutian Islands have changed little in the last two decades, and continue to be dominated by Atka mackerel, salmon, Pacific cod, walleye pollock, Irish lords, and rockfishes.

Reproductive, metabolic, and inflammatory parameters of beluga whales (Delphinapterus leucas) sampled from Bristol Bay, Alaska

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Rapid changes are occurring in northern environments due to climate change, increased human activity, and resource development. As a top predator, beluga whales (Delphinapterus leucas) are important sentinels, reflecting the health of their environment and amplifying the effects of changes from across the marine ecosystem. Health assessments of Bristol Bay belugas, an expanding and presumably healthy population, help establish baseline values prior to projected development in that area and provide comparative data to better understand the lack of recovery of endangered populations such as Cook Inlet belugas. Live captures of Bristol Bay belugas were conducted to perform health assessments, collect biological samples, and provide a platform for related integrative studies with collaborating institutions (NMFS Marine Mammal Research Permit No. 782-1719-07, 932-1489-10, and 14245-01). Blood samples were collected from 27 belugas in May (n=10) and September (n=8) 2008, and September 2012 (n=9). Archived serum was analyzed for fibrinogen, an indicator of inflammation, and thyroid and reproductive hormones. In 2008, mean ± SD levels were 115 ± 35 mg/dL for fibrinogen, and for thyroid hormones were 8.14 ± 2.18 ug/dL (tT4), 0.99 ± 0.27 ng/mL (tT3), and 3.14 ± 0.62 ng/dL (free T4). In males, testosterone was below detectable limits in juveniles (n=3) and averaged 1.33 ± 0.54 ng/mL in adults (n=4). Reproductive hormones, including progesterone, varied between pregnant (n=4, >40 ng/mL) and juvenile females sampled in May (n=3, 0.22 ±0.17 ng/mL) and September (n=3, 0.30 ±0.36 ng/mL) 2008. Similarly, estradiol levels were greater in pregnant (40.80 ± 10.27 pg/ml) compared to juvenile females sampled in May (16.08 ± 6.32 pg/ml) and September (12.38 ± 3.88 pg/ml) 2008. An eighth presumed nonpregnant adult female was sampled in May 2008 and had a progesterone level of 16.89 ng/mL and estradiol of 36.80 pg/ml. These data, combined with ongoing monitoring efforts, contribute to the management of Bristol Bay belugas, and provide a means of comparing health measures from this healthy, growing population to that of other populations such as the endangered Cook Inlet belugas.

Proximate composition of northern fur seal milk: sources of variability and comparisons between Bering Sea rookeries with contrasting population trends

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Knowledge of the composition of northern fur seal milk is needed to examine the energetics of pup growth and body condition at weaning, two necessary factors in evaluating the possible reasons for divergent population trends of fur seals on the Pribilof Islands (continental shelf, declining population) and Bogoslof Island (Aleutian Islands, deep basin, growing population). In this study we collected milk samples from female fur seals at St. Paul Island (Pribilofs) and Bogoslof Island in 2005 and 2006 during the perinatal period in early July and again near the end of the breeding season in October, approximately three-fourths through the lactation period. Island, rookery, year, days post partum, preceding foraging trip duration, time ashore, female mass, July milk composition, and milk withdrawal volume were used as independent variables in multivariate regression analyses to identify sources of variability in milk composition. There was no difference in the composition of milk from females at the two islands in July (lipid ~ 46%, protein ~ 10%, and energy ~ 21 KJ/g; $p \geq 0.16$). In October, the factors, island, time ashore, days postpartum, preceding trip duration, and July milk composition explained variability in milk lipid and the factors time ashore, days postpartum, and July milk composition explained the variability in milk energy content. October lipid content averaged 53.8±1.0% at St. Paul Island and 57.3±0.8% at Bogoslof Island ($p < 0.01$) and energy content averaged 24.0±0.4 kJ/g at St. Paul Island and 25.2±0.3 kJ/g at Bogoslof Island ($p = 0.11$). On average milk lipid content increased 22% from July to October, protein remained relatively stable with averages ranging between 10.0% and 10.5%, and total energy content increased by 20%. The lipid content of northern fur seal milk near peak lactation is the highest reported among otariid seals and is comparable to the highest known for phocid seals, making it among the highest known for all mammals. This is consistent with the short lactation length and long foraging trip durations typical in northern fur seals.

Immune parameters and function in Beluga (*Delphinapterus leucas*) sampled from Bristol Bay, Alaska

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Due in part to population declines, climate change and industrial development there is increasing concern for the conservation and management of the five stocks of beluga (*Delphinapterus leucas*) within Alaskan waters. The population trends vary greatly for the different management stocks with the Bristol Bay stock currently increasing an estimated 4.8 % annually. Therefore, there is an interest in performing health assessments and establishing baseline values for several immune parameters in the apparently healthy and growing population of Bristol Bay that can also serve as a comparison for stocks with declining populations, such as Cook Inlet. To this end, blood samples were collected from 27 belugas in 2008 (n=18) and 2012 (n=9). Samples were collected in collaboration with other research efforts (NMFS Marine Mammal Research Permit Nos. 782-1719 (2008) and 14245 (2012)) and in cooperation with the Bristol Bay Native Association, Bristol Bay Marine Mammal Council, and the Alaska Beluga Whale Committee. Blood samples were used for complete blood cell counts including total and differential white blood cell counts and for the isolation of peripheral blood mononuclear cells (PBMC). Archived PBMC were used for assessing the adaptive immune system, as measured by lymphocyte proliferation assay and immunophenotyping subpopulations of lymphocytes. Belugas sampled in 2008 averaged (± SD) a total white blood cell count of 18507 ± 1128 with differential counts as follows: neutrophils 6576 ± 435; monocytes 1199 ± 203; lymphocytes 6500 ± 535; and eosinophils 4221 ± 375. Monoclonal antibodies specific for cell surface proteins on lymphocyte were used to identify lymphocyte subsets. As previously reported in belugas, the majority of the lymphocytes were MCH class II+ (92.1 ± 3.8 %). The remaining subtypes of lymphocytes identified were cytotoxic T cells (1.6 ± 1.1 %), T helper cells (31.1 ± 5.9 %) and B cells (8.9 ± 4.3 %). Following the incorporation of the 2012 samples, the present study will provide information on the health and immune function of the Bristol Bay beluga population which is relevant for the management of that stock and which may serve as a comparison for other free-ranging beluga populations.

Bering Sea - Mammals

Temporal trends of persistent organic pollutants, trace elements, and vitamins in St. Paul Island northern fur seals

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Persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs) and perfluorinated alkyl acids (PFAAs) and mercury, readily accumulate in Alaska marine wildlife, particularly marine mammals. POPs in Alaska originate mainly from lower latitude regions reaching Alaska by atmospheric and ocean routes where they are biomagnified in marine food webs reaching the highest levels in predatory marine mammals. Once in the food web, POPs and mercury can affect both the health of wildlife and the health of humans using them for food. Understanding the time trends of POPs and trace elements in the marine environment is important to show the effectiveness of controls on releases, validate predicted changes in levels resulting from global warming, and highlight increasing trends of "new" POPs currently in regional and global use. In Alaska, time trends of POPs and trace elements in marine wildlife are particularly needed to help place trends in an arctic perspective as there are relatively few temporal trend studies on Alaska marine wildlife compared to most other regions. To fill this gap, the National Institute of Standards and Technology (NIST) has conducted several studies using marine mammal samples from the Alaska Marine Mammal Tissue Archival Project's collection in NIST's Marine Environmental Specimen Bank to define time trends of contaminants in Alaska's marine environment. From 1987 to 2007, blubber (n=50) and liver (n=49) samples were collected from juvenile male northern fur seals (Callorhinus ursinus) through subsistence hunts from rookeries at St. Paul Island. Samples were analyzed for many legacy (PCBs, DDTs etc.) and current-use POPs (PFAAs, brominated flame retardants), trace elements and vitamins. Concentrations of certain PFAAs (odd-chain length compounds) and current-use brominated flame retardants in northern fur seals are increasing significantly with time. Likewise, mercury concentrations in the northern fur seal liver significantly increased during the 20 year time period. Data for other POPs (including legacy POPs) are still being compiled. The complete data set will help to place contaminant trends in the Alaska marine environment in both a regional and global perspective.

Bering Sea - Mammals

Intra- and inter-island differences in the foraging behavior of northern fur seals from the Pribilof Islands, Alaska

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Ashmole's "halo effect" suggests that high levels of intra-specific competition by central place foragers can lead to depletion of prey around breeding areas. To reduce the impact of this competition both within and between colonies, individuals can forage in more distant areas or colonies can segregate foraging areas. We examined this phenomenon for northern fur seals (*Callorhinus ursinus*) breeding on the Pribilof Islands, Alaska (St. Paul Island [SPI] and St. George Island [SGI]). We compared dive behavior, movement patterns, and foraging range both within and between islands to determine if there was evidence for vertical and horizontal habitat segregation. We predicted intra-specific competition for foraging sites would be reduced by fur seals from each island using different foraging habitats or different regions of the water column when foraging ranges overlapped. Between islands there was evidence for horizontal habitat segregation as very little overlap occurred in foraging areas. Between rookeries on SGI, there was nearly 100% overlap in foraging areas, whereas at SPI there was significant habitat segregation among rookery complexes. For both islands there were no differences in dive behavior among rookeries, suggesting vertical habitat segregation does not occur even when animals forage in similar areas. The differences found in habitat segregation are likely due to the different levels of intra-specific competition faced at each island. The fur seal population on SPI is significantly larger and pup production is over 5 times greater than on SGI. As a result of this high level of intra-specific competition, fur seals from SPI also use a significantly larger foraging area and forage in more diverse habitats than those on SGI. By comparing foraging behavior between these divergent colonies we may gain greater insight into the effects of resource depletion, which can help guide conservation efforts for this depleted species.

Bering Sea - Mammals

Gastrointestinal helminthes of northern fur seals (*Callorhinus ursinus* Linnaeus, 1758) on St. Paul Island, Alaska: current changing in parasite community structure

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Northern fur seals (NFS) (*Callorhinus ursinus* L., 1758) are parasitized by more than 20 species of gastrointestinal helminthes of four systematic groups (Nematoda, Cestoda, Trematoda, Acanthocephala). Most of these parasites have an indirect life cycle involving intermediate/paratenic hosts (crustacea, fishes, squids) which are sources of NFS infection. The aims of our study were determination of NFS infection with various groups of gastrointestinal helminthes and analysis of the current state of parasite community structure. Our study was carried out during July-August 2011 and 2012 on St. Paul Island, Alaska. Gastrointestinal tracts of 406 subadult males (3–4 years old) were collected during the annual NFS Aleut subsistence harvest. All helminthes were collected, fixed in 70% ethanol and identified by morphological criteria. Totally, 3,685 specimens of nematodes, 6,183 cestodes, 578 trematodes and 483 acanthocephalans were collected. Numbers of stomach nodules and ulcers caused by gastric nematodes also were calculated. All NFSs examined were infected by gastrointestinal helminthes. Prevalence of NFS infection by gastric nematodes was 71.9%; mean intensity of infection was 10.5±14.2. Four species of *Anisakis* (*A.simplex*), *Contracaecum* (*C.osculatum*) and *Pseudoterranova* (*P.decipiens, P.azarazi*) were found. Prevalence of NFS infection with cestodes was 97%; mean intensity – 15.7±13.9. Five cestode species of Diphyllobothrium (*D.pacificum, D.lanceolatum, D.hians, D.romeri*) and *Diplogonoporus* (*D.violettae*) were registered. Prevalence of NFS infection with trematodes was 34.2%; mean intensity – 5.61±9.1. Prevalence of infection with acanthocephalans was 39.4%; mean intensity – 3.1±3.2. Seven species of *Corynosoma* (*C.strumosum, C.alaskensis, C.semerme, C.similis, C.validum, C.villosum*), and *Bolbosoma* (*B.nipponicum*) were found. Comparison of current data with data of previous researchers reveals changes in NFS parasite community structure. We observed a decrease in prevalence of NFS infection with anisakids (*Contracaecum* and *Pseudoterranova*), and decrease in number of stomach nodules and ulcers (from 92% to 20.7%). Intensity of infection by all groups of helminthes significantly decreased (from hundreds of worms in the early 1960s to dozen of worms now). As marine parasites are considered as indicators of food chain structure in marine ecosystems, further studies are necessary to reveal the main reasons of such changing in the NFS parasite community structure.

Development and field testing of satellite-linked fluorometers for marine mammals: shedding light on the unknown

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Understanding the responses of marine mammals and other apex predators to spatial and temporal variability of primary productivity is fundamental for their management and for predicting how they will be affected by future climate change. Attaining this goal is often hampered by paucity of oceanographic data, but the use of animal-borne platforms as environmental sensors is quickly emerging to complement traditional oceanographic data collection methods, sample remote or inaccessible locations, measure and map three-dimensional oceanographic data, and provide real-time data of animal behavior corresponding to the abiotic vertical structure of the water column. Despite recent advances in biotelemetry, however, fluorometers have not been incorporated into transmitting systems. The purpose of this project is to incorporate a miniature fluorometer into a satellite-linked transmitter to provide measures of in situ phytoplankton fluorescence, which will be used to calculate chlorophyll-a (chl-a), a proxy for primary productivity. After evaluating the suitability (i.e. size, power consumption, and electronic interface) of commercially available fluorometers, the Combo Fluorometer-Turbidity Unit (FLNTU; WET Labs, Inc., Philomath, OR), which measures chl-a (0 – 75 µg Chl/l) and turbidity (0-200 NTU), has been interfaced with an archival instrument (Mk10, Wildlife Computers, Ltd., Redmond, WA). Future field tests, including deployment on an oceanic remote chemical analyzer, will be used to validate data, optimize data compression for eventual satellite transmission, and assess sampling rates, duty cycles, and overall reliability. Trial periods with marine mammals, including Alaskan pinnipeds, will also address concerns related to sensor orientation and fragility, biofouling, and measurement error and noise.

Iliamna Lake freshwater seal ecology: utilizing Local Traditional Knowledge and western science

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In response to concerns about the absence of information on the status of the freshwater seals within Iliamna Lake, Iliamna Lake communities have partnered with the Bristol Bay Native Association, UAA, ADF&G, and NOAA to gather scientific and local traditional knowledge (LTK) data documenting seasonal shifts in abundance and distribution of the unique freshwater seal population. Methods included aerial surveys, biosampling, ethnographic LTK interviews, harvest surveys, and mapping. This project, NPRB Project 1116, is a continuation of NPRB Project 906. This current project compares findings from this earlier project as well as 2004 and 2005 harvest and use data collected by ADF&G. This paper will present preliminary results from aerial surveys and analysis of tissue samples received from seal hunters in Iliamna Lake communities. Tissue samples are enabling researchers to understand migration and possible delineation in harbor seal populations between Iliamna Lake and Bristol Bay. Other activities with preliminary results include data derived from harvest surveys, LTK interviews, and mapping conducted in 2012 in the communities of Iliamna, Newhalen, Kokhanok, Igiugig, Levelock, and Pedro Bay. Surveys included working with tribal governments, local research assistants, and school students. The final report under development compares and contrasts LTK with data obtained using scientific techniques to understand the harbor seal population in Iliamna Lake within the broader social-ecological system.

Uncinaria lucasi in northern fur seals (*Callorhinus ursinus*) on St. Paul Island, Alaska: "endangered species" or hidden danger?

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Hookworms (*Uncinaria lucasi*) first were reported in northern fur seals (NFS) (*Callorhinus ursinus* L., 1758) on the Pribilov islands in 1896 (Lucas, 1899). In the 1950-60s, prevalence of U. lucasi in NFS pups was 100% on some rookeries. Then hookworms were the main cause of death of NFS pups on the Pribilov islands. Extensive research on biology and ecology of hookworms on St. Paul Island (SPI) was started in the 1950s. Periodic monitoring of hookworm infection in dead NFS pups has been performed since then. Dramatic decrease of the NFS population was observed on the Pribilov Islands during the last several decades – from 300-400,000 in the 1950-60s to a little more than 120,000 in the early 2000s. Prevalence of U. lucasi in pups also declined dramatically – from 90% in 1970s to 3-6% in 2007-2011. U.lucasi has been considered an "endangered" species on SPI and therefore having no negative effect on NFS populations. Studies performed in 2012 made us reconsider this point of view. In July-August 2012, we searched for hookworms in the intestines of 43 freshly dead NFS pups from three rookeries – Reef (rocky rookery), Vostochny and Morjovy (sandy rookeries). Freshly dead pups were undergone to complete necropsy; all intestines were examined for hoorworms. No hookworms were found in pups from Reef rookery, but prevalences in pups on Vostochny and Morjovyj rookeries were 50% and 75%, respectively. Intensity of infection was from 1 to 154 (average=47.8) hookworms. Although only a small number of pups was examined, results in 2012 suggest that uncinariosis is still a potentially hidden danger for the NFS population on the Pribilof Islands, especially on sandy rookeries. Prevalence of NFS hookworm infection on sandy rookeries is comparable with data of Russian researchers who reported high prevalence and death of NFS pups from hookworms on Commander Islands (Kolevatova et al., 1998). Further monitoring of U. lucasi on the Pribilof Islands is necessary to ascertain whether these parasites may be a factor causing decline of the NFS population in the Bering Sea.

Ice-associated seal detection and identification from the 2012 Bering-Okhotsk Seal Surveys (BOSS)

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Advances in imaging technology have allowed aerial surveys for seals on sea ice to be conducted from altitudes higher than visual-observation surveys, while maintaining or increasing the effective survey strip width and reducing or eliminating the seals′ response to the survey aircraft. Extracting data from the hundreds of thousands of images that may be collected during a survey, however, can be onerous. In the spring of 2012, we conducted a survey for bearded, spotted, ribbon, and ringed seals in the Bering Sea, collecting over 885,000 images and 300 hours of thermal (infrared) video. The thermal video was used to detect the warmth emitted by seals against the cold background of the sea ice. High resolution digital color images were used for species identification. Pairing these two instruments provided significantly faster and more accurate detection over manual image analysis. The color images provided a basis for quantifying the accuracy and precision of species classification, enabling us for the first time to incorporate misclassification error into the precision of seal abundance estimates.

Body condition and caloric demand of female Pacific walruses

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With declining sea ice availability, walruses are increasing their use of terrestrial haul-outs, which could deplete localized prey resources. Estimates of caloric demand and techniques for monitoring body condition are required for assessing the potential for population level effects on walruses. Caloric intake and body condition (length, girth, mass, and blubber thicknesses) were measured monthly over one year from non-reproductive female walruses housed at Indianapolis Zoo (n = 1; Tair = 18.7 ± 14ºC, Twater = 12.2 ± 0.1ºC), Six Flags Discovery Kingdom (n = 2; Tair = 19.6 ± 6 ºC, Twater = 13.9 ± 4.5ºC), and Point Defiance Zoo and Aquarium (n = 2; Tair = 13.8 ± 7ºC, Twater = 10 ± 2ºC). These individuals had an average (±SD) annual body mass of 683 ± 11, 747 ± 14, 764 ± 28 kg, 716 ± 28 kg, and 936 ± 27 kg comprised of 24 ± 2, 26 ± 2, 27 ± 2%, 27 ± 1%, and 30 ± 1% blubber, respectively. These body conditions were maintained with an average of 31,249 ± 4,449, 25,847 ± 4,100, 20,123 ± 4,247, 23,062 ± 5,448, and 29,403 ± 4,474 kcal dy^{-1}. Based on our published bioenergetics model, these caloric intakes represent 61%, 47%, 35%, 45%, and 48% of those required by wild non-reproductive female walruses of equivalent body size. Much of this discrepancy is likely due to differences in activity level between captive and wild animals, as our bioenergetics model assumed that animals are active 83% of the time. Nonetheless, the basic physiology measured from animals in human care provides bounds on parameters used in bioenergetic models and serves as a basis for developing criteria for assessing body condition of wild walruses.

Bering Sea - Mammals

The 'Bigg' picture: evidence for seasonally sympatric populations of Bigg's killer whales

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Bigg's (or 'transient') killer whales (*Orcinus* sp.) are one of three ecotypically distinct North Pacific lineages. Feeding almost exclusively on marine mammals, Bigg's killer whales occupy the apical niche in the marine ecosystem. As apex predators in the productive high latitude waters around the Aleutian Islands, a detailed understanding of the ecology, distribution and structure of killer whale stocks is a critical component of ecosystem models and the conservation and management of marine resources. Here we draw inference from over a decade of behavioral observations and photographic resighting data to interpret molecular genetic data generated from the analysis of individual biopsy samples collected throughout the Aleutian Islands. Both mitochondrial control region sequences (980bp) and multilocus nuclear microsatellite genotypes (26 loci) were generated for each sample (n=140), and duplicate samples were identified by direct comparison of both genotypic and photographic identification data. Measures of genetic differentiation were estimated for putative population strata that were defined based on photographic resighting data. Genetic clustering algorithms were used to further explore population genetic structuring throughout the Aleutians. Geographic patterns of genetic differentiation and regions of genetic discontinuity provide significant evidence for the presence of several large population clusters, in contrast to the current stock designation for Bigg's killer whales that recognizes a single 'Aleutian and western' stock. Interestingly, our results also indicate the existence of a smaller sympatric population around Unimak Island in the eastern Aleutians. These findings corroborate direct observations suggesting a seasonal influx of mammal-eating killer whales in this region coincidental with migrating gray whales (*Eschrichtius robustus*). Evidence for seasonally sympatric genetic clusters within Bigg's killer whale populations suggests the presence of isolating mechanisms other than geographic distance within this highly mobile top predator.

Bering Sea - Mammals

Pacific walrus haulout disturbance and recovery

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The Pacific walrus is listed as a "Candidate Species" under the Endangered Species Act, primarily due to concerns over reductions in their sea ice habitat. Loss of habitat poses a serious threat to the long term sustainability of Pacific walruses. A potential impact on female and calf terrestrial haulout use is calf mortality due to disturbance. The overall goals of this project were to monitor terrestrial walrus haulout locations and assess attendance, duration, level of disturbance and recovery time. Digital still cameras were mounted at five terrestrial Pacific walrus haulouts. At each site one or more cameras faced the primary haulout to record animal abundance, duration, and reactions to disturbance. An additional camera focused on the immediate water access to record potential causes for disturbances. These camera observations were a non-invasive means to collect long term data with little to no disturbance to the study animals. Disturbances were recorded by boats on the water, boats landing on the beach, human foot traffic, and aircraft. Level of disturbance and recovery time elevated with repeated occurrences on the same day.

Can changes in Atka mackerel quality contribute to Steller sea lion declines in the western and central Aleutian Islands?

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The Junk Food hypothesis states that the quality of certain prey items dominant in the diets of Steller sea lions may be insufficient to meet their energetic requirements, leading to nutritional stress and population declines. We tested whether there was a physiological basis for the observed link between decreasing Steller sea lion numbers and high levels of consumption of Atka mackerel in the western and central Aleutians. Atka mackerel appears to be a nutritionally "reasonable" species, but it varies considerably in quality throughout year. The cyclical seasonal nature of changes in Atka mackerel quality combined with the seasonal changes in energy requirements of sea lions, suggests the potential for deleterious interactions to occur between the bioenergetics of sea lions and Atka mackerel. We tested this concept by feeding seasonally-appropriate Atka mackerel or herring to captive Steller sea lions at varying planes of nutrition to determine the potential differential effect on individual sea lion growth (mass, composition) and physiology (metabolism, haematology). Steller sea lions fed Fall Atka mackerel (August – October) — which is comparable in composition to the herring fed as a parallel diet during our trials — had to consume significantly (30%) more energy from Atka mackerel than herring to maintain body mass, despite the minimal difference in lipids and energy content between these prey at this time of year. However, there were no prey-related differences in other physiological indicators if appropriate levels of energy were provided. However, during the Spring trials (April – June; a time critical for growth) Atka mackerel contains significantly less lipid and energy than herring. In general, sea lions fed the leaner Atka mackerel during the Spring had more difficulty maintaining lipid stores and body mass, particularly when subject to restricted food intake levels. These results are consistent with previous studies indicating that decreased prey quality has an additional detrimental effect on Steller sea lion condition, especially when coupled with inadequate intake levels. These results also suggest a potential physiological mechanism by which consumption of high levels of Atka mackerel during key times of the year could explain decreases in Steller sea lion numbers.

Bering Sea - Mammals

Histological features of the gastrointestinal track of northern fur seals (*Callorhinus ursinus*) associated with helminthes at St. Paul Island, Alaska

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Northern fur seals (NFS) (*Callorhinus ursinus* L., 1758) are parasitized by more then 20 species of gastrointestinal helminthes of four systematic groups – Nematoda, Cestoda, Trematoda and Acanthocephala. Gastric parasites are mainly Nematoda of three genera: *Anisakis, Contracaecum* and *Pseudoterranova*; four nematode species (*A. simplex, C. osculatum, P. decipiens, P. azarazi*) were found in NFSs from St. Paul island, Alaska. Helminthes that primarily inhabit the ileum, caecum and upper large intestine include Cestoda, Trematoda and Acanthocephala. Five species of Cestoda (*Diphyllobothrium pacificum*, *D. lanceolatum*, *D. hians*, *D. romeri* and *Diplogonoporus violettae*) and 7 species of Acanthocephala (*Corynosoma strumosum*, *C. alaskensis*, *C. semerme*, *C. similis*, *C. validum*, *C. villosum* and *Bolbosoma nipponicum*) have been documented in NFSs there. During July-August 2011 and 2012 we examined gastrointestinal tracts of 406 subadult males (3–4 years old) that were collected during the annual NFS Aleut subsistence harvest. All helminthes were collected and fixed in 70% ethanol for identified by morphology. Numbers of stomach nodules and ulcers caused by gastric nematodes were calculated. Gross and histological lesions associated with the gastric helminths have been described and include nodules and healed and active ulcers surrounded by granulomatous inflammation; whereas only mild to moderate chronic active inflammation has been seen in the caecum, ileum and upper large intestine in the late 1980′s and early 1990′s. There has been a decline in the gastrointestinal parasites from the mid 1950-60′s to the late 1980-early 1990′s. Preliminary data from 2011-2012 also documents a continued decline in gastrointestinal parasites – even prevalence of NFS infection with Nematoda was 71.9%; mean intensity of infection was only 10.5±14.2. The same situation was observed with other groups of helminthes. There was a decrease in number of stomach nodules and crater-like ulcers in NFS from 92% to 20.7% comparing with previous decades. The degree of inflammation associated with the Cestoda, Trematoda and Acanthocephala was similar to the lesions work published in the 1980-1990′s. Further studies are necessary to monitor dynamics of prevalence and intensity NFS infection by gastro-intestinal parasites to understand current trends of ecosystems development in Bering Sea.

Spatio-temporal distribution of fin whales in the Bering Sea, 2007-2011

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The National Marine Mammal Laboratory has been collecting passive acoustic recordings of vocalizing marine mammals through much of the southeastern Bering Sea since 2000. The present analysis combines these recordings with those obtained in 2007 from a North Pacific Research Board-funded study (Stafford and Mellinger) to determine the long-term spatio-temporal distribution of fin whales throughout the Bering Sea shelf. A total of 28 moorings (19 Autonomous Underwater Recorders for Acoustic Listening (AURALs); 9 Ecological Acoustic Recorders (EARs)) were deployed year-round from October 2007 to September 2011 at varying depths and locations along the Bering Sea shelf, from Umnak Pass to just south of St. Lawrence Island. Preliminary analyses show an annual southward movement of calling fin whales in winter, seemingly associated with the expanding ice edge; these results will be compared with 1-day composite ice cover measured by the Advanced Microwave Scanning Radiometer for the Earth Observing System (NOAA Coastwatch). Furthermore, the results show a considerably lower number of calls detected south of St. Matthews compared to the other mooring locations. In addition, overall fin whale seasonal calling trends along and between the 50m and 70m isobaths, and the species′ use of Umnak Pass and Unimak Pass will be described. [Work supported by the Bureau of Ocean Energy Management]

Modeling suitable foraging habitat for adult female northern fur seals (*Callorhinus ursinus*) and implications for conservation of a declining species

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Conservation of free ranging marine predators often relies on determining the habitat needs of a species and instituting protective measures in the most important areas. Defining key areas of use is crucial for the management of a declining species such as the northern fur seal. The aim of this study was to develop a habitat suitability model using locations of diving from 22 lactating-adult northern fur seals instrumented on the Pribilof Islands, Alaska. Ecological Niche Factor Analysis (ENFA) was used to model fur seal foraging in relationship to sea surface temperature, bathymetry, sea surface height, and ocean productivity in September 2004 in the eastern Bering Sea. Habitat suitability was calculated from the first three factors from the ENFA that explained 92% of the variance in the data set. Four types of fur seal foraging habitat were defined: optimal, suitable, marginal and unsuitable. Optimal foraging habitat was cooler, more productive, and shallower than average across the 778,430 km^2 study area. The model was evaluated using the k-fold cross-validation method and the Boyce Index (0.91, SD ± 0.088) indicated it was both robust and had high predictive power. Due to potential overlap in prey resources with commercial fisheries, we determined the catch distribution of walleye pollock in each of the four habitat types defined by the model: 83% was caught in optimal, 12% in suitable and only 5% was taken in areas classified as marginal or unsuitable. While most fur seal diving occurred in optimal and suitable habitat (by definition), both the proportion of fur seals that gained weight and the average percent change in weight decreased with increasing overlap between the pollock fishery on the outer continental shelf and fur seal dive locations from each rookery. Our model demonstrates a readily available and robust method for predicting important fur seal foraging habitat and for identifying potential areas of competitive interactions with fisheries.

The role of contaminants on western Steller sea lion survival and movement in the Russian Far East

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This study examines the relationship between organochlorine contaminants (OCs) and the poor recovery of the western stock of Steller sea lions (SSL) at rookeries in the Russian Far East. In 2002 OC concentrations were quantified from 136 hot-branded SSL pups from four Russian rookeries (Iony I. n=26, Yamsky n=33, Medny I. n=39, Kozlova Cape n=38), and brand-resight data was collected from this region in 2003-2011 from both rookeries and haulouts. Using the brand-resight data in conjunction with quantified OC concentrations we made a preliminary investigation of the role of contaminants on this segment of the SSL population. Mark-recapture analyses showed that pup survival to age 1 was estimated to be 59 ± 4.75%, while survival at age 1+ is 89 ± 1.64%. This is consistent with the expectation of lower survival of pups in their first year than that for juveniles and mature large mammals. This high mortality rate could help to explain the lack of robust recovery at some rookeries. Multi-state mark-recapture models analyzed in program MARK showed that contaminants do not explain model variability better than the models which did not include contaminants. The estimates of survival were statistically unchanged when accounting for contaminants, using ΔAIC as the criterion. The probability of movement between rookeries and regions was also investigated. Initial results showed that the estimated probability of SSL movement after their first year from Bering Island to Medny Island was 40%, and that from Medny Island to Kozlova Cape was 33%. The estimated probability of movement of animals from the Sea of Okhotsk rookeries to Kozlova Cape or Medny rookeries, or vice versa, was minimal with the largest estimate being 17% for movement from western to eastern rookeries or to haulouts. Because of small sample size, the potential for effects of OCs on SSL remains unclear.

Gulf of Alaska - Ecosystem Perspectives

Tracing carbon and hydrogen isotopes from glacial freshwater to coastal marine food webs

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In the Gulf of Alaska, freshwater input maintains the density gradient that drives the Alaska Coastal Current and influences marine productivity in coastal areas. Nearly half of the freshwater discharge into the Gulf of Alaska may originate from melting glaciers. Dissolved organic matter (DOM) in glacial rivers is unique compared to DOM in other river types because the ancient carbon it contains is more bioavailable to marine microorganisms. To demonstrate linkages between terrestrial and marine ecosystems, we are using stable and radio isotopes to estimate the relative contribution of glacially-derived organic matter and freshwater to marine food webs. During summer 2012, we sampled dissolved and particulate organic matter, zooplankton, forage fish and seabirds near tidewater glaciers in Prince William Sound, Alaska. We also collected water samples to measure the extent of mixing and infiltration of glacial melt water in the marine system. We anticipate that stable isotope (deuterium and carbon) and radiocarbon signatures of lower trophic marine organisms will permit us to trace glacier-derived freshwater and organic matter in marine food webs owing to the markedly different isotope ratios between glacio-terrestrial versus marine hydrogen and carbon sources. We also expect hydrogen and oxygen isoscape mapping to clearly show the pattern of freshwater mixing into the marine environments. Given the predicted impact of global warming on glaciers and freshwater flow, this work will enhance our understanding of the role of glaciers on coastal marine ecosystems in the Gulf of Alaska.

Examining genetic diversity of an invasive colonial ascidian in southeast Alaska

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In 2010, an isolated population of the invasive colonial ascidian, *Didemnum vexillum*, was discovered during a Bioblitz survey in Whiting Harbor, Alaska. Believed to be native to Japan, *D. vexillum* has now been reported in Europe, New Zealand and North America. As *D. vexillum* is an aggressive invader, and many communities in Alaska depend on their relatively pristine natural environment for economic and cultural practices, this invasion has become a significant cause for concern. Examining the possible pathways of *D. vexillum* to Whiting Harbor will allow us to learn how *D. vexillum* spreads and possibly how future invasions can be prevented. In order to characterize this invasion, we sampled the Whiting Harbor population, and compared it to other studies of *D. vexillum* populations around the world. We genotyped 31 specimens from around Whiting Harbor at a 586-bp fragment of the mitochondrial cytochrome oxidase subunit I (COI). We found three haplotypes with a haplotype diversity of 0.5720 ± 0.0453. When compared to previously reported haplotype diversities of other locations around the Pacific ocean, where *D. vexillum* originated, we find it is lower than Japan and the western coast of North America (first reported in 1993), but higher than the population in New Zealand (2001). It is expected that an older invasion would have higher diversity than a newer one because it has had more time for continued or diversely sourced inoculations. Possible explanations for why the newer Alaska invasion has a higher diversity than New Zealand are having a higher rate of repeated invasions, or having established earlier than first detected. To better understand the source population(s) of *D. vexillum* in Alaska, we are investigating further with comparisons using nuclear loci.

Monitoring nearshore marine ecosystems in the Gulf of Alaska: Detecting change and understanding cause

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Nearshore marine habitats support unique and valued ecosystem services. Shallow marine habitats and primary production provided through kelps, other seaweeds, and seagrasses contribute to a distinctive food web where benthic invertebrates transfer energy to higher trophic levels. Since 2002, a multi-agency effort has designed, tested and implemented a nearshore monitoring program that focuses on intertidal algae and sea grasses as primary producers, benthic invertebrates such as mussels, limpets, and clams as primary consumers, and sea stars, black oystercatchers and sea otters as apex consumers. Monitoring population trend, diet, and demographics of consumers, while simultaneously monitoring metrics such as density and size distributions associated with the primary producers and primary consumers, will help to identify potential causes of change and influence management activity. In 2011, our monitoring program was integrated into the Gulf Watch Alaska long-term monitoring program, focusing on Gulf of Alaska marine ecosystems and allowing us to expand our area of monitoring and our capacity for inference. The larger program is sponsored by several agencies, universities and NGO's, and includes the nearshore, the pelagic, and ecosystem drivers that influence marine systems. For example, the nearshore system is functionally connected to both oceanic and terrestrial ecosystems. Processes such as water exchange, sediment deposition, and exchange of organisms and other drivers that influence production build intricate ecosystem connections. Here we describe the ongoing monitoring of the nearshore food web and identify ways in which monitoring multiple marine environments and food webs at a variety of spatial scales can provide understanding into the scale and causes of change within and across ecosystems.

The 2013 Alaskan observer program by the numbers

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Changing how observers are deployed into the Alaskan fishing fleet has been a focus of the Alaska Fisheries Science Center and the Alaska Regional Office since 1992. The switch from a deployment system whereby fishers decide which events are observed to one where such decisions are under Agency control requires the development of observer contracts, a scientific deployment plan, programming infrastructure, outreach efforts and regulations. This poster depicts the quantities of individual elements that together comprise the most recent effort to “restructure” the North Pacific Groundfish (and Halibut) Observer Program that began in April 2010 and is expected to be implemented in 2013.

Gulf Watch Alaska – Ecosystem monitoring at the intersection of spilled oil and climate change

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Two decades after the Exxon Valdez oil spill (EVOS), an integrated, long-term program has evolved to monitor both the species injured by the spill and the marine conditions that affect those species. Now known as Gulf Watch Alaska, this ecosystem monitoring program is supported by the EVOS Trustee Council and builds on extensive past research and monitoring efforts. The program is in the first 5-year phase of a planned 20-year effort. It covers broad coastal ecosystem aspects from oceanography to nearshore and pelagic food webs and includes integration of the monitoring data to better understand how species changes are linked to environmental conditions and across trophic levels. Monitoring is organized under three focal areas of oceanography, benthic species and pelagic species and is being conducted in Prince William Sound, lower Cook Inlet and portions of the central Gulf of Alaska coast. Highlights from the program’s first field season, completed in 2012, will be provided, as well as a summary of initial historical data synthesis efforts. Monitoring information is valuable for assessing sustained recovery of injured species, managing those resources and the services they provide, and informing the communities who depend on the resources. The ultimate goal of Gulf Watch Alaska is to provide managers and the public with the long-term, consistent scientific data needed to allow us to detect and understand ecosystem changes and shifts that directly or indirectly (e.g., through food web relationships) influence the species and services injured by the Exxon Valdez oil spill. Going forward, we aim to also improve the ability to predict and prepare for potential Gulf of Alaska ecosystem changes that may be associated with climate change.

Seasonal variability in phytoplankton and oceanography in Kachemak Bay, Alaska

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Phytoplankton are the base of marine food webs and though phytoplankton species may be present in an ecosystem most of the time, changes in environmental conditions, such as an influx of nutrients or a rise in temperature, can lead to a sudden increase in their abundance. If this increase occurs in a species that produce toxins or causes other harm it is referred to as a harmful algal bloom, or HAB. Kachemak Bay, located on Cook Inlet in south-central Alaska, is subject to HAB events and there is little data on phytoplankton abundances, distributions and temporal variability. The goal of this study is to provide baseline information on Kachemak Bay phytoplankton species and associated oceanographic conditions. We seek to improve understanding of seasonal variability in phytoplankton communities and of environmental drivers for HABs. In January 2012 we began a weekly phytoplankton sampling program near NOAA's Kasitsna Bay Laboratory. We focused on *Chaetoceros* spp., the most abundant species and a cause of juvenile fish mortality in hatchery pens, and *Alexandrium* spp., which have been implicated in HABs along the south-central and southeastern coasts of Alaska. Surface samples were collected with a net from two dockside locations and visually identified and enumerated using a light microscope and volumetric Palmer counting cells. Concentration estimates (cells per liter) were made for each species. As expected, concentrations increased markedly from low or undetectable values in the winter to very high (over 200,000 cells per liter for *Chaetoceros* sp.) concentrations in the summer. *Chaetoceros* spp. abundances remained high throughout the summer while *Alexandrium* spp. concentrations were very low most of the time, which may partially reflect differing species responses to temperature and salinity changes. Study results provide baseline information on the Kachemak Bay phytoplankton and are being used to improve existing plankton monitoring programs in collaboration with the Kachemak Bay National Estuarine Research Reserve and NOAA's Phytoplankton Monitoring Network. Future research will investigate the influence of ocean circulation patterns and stratification on phytoplankton, along with temperature and salinity conditions, ultimately to predict how climate change will affect the plankton community and HAB events.

Impacts of sea otter recolonization on kelp forest communities in Southeast Alaska

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Interdisciplinary research is needed to study the effects of top-level predators on process, function, and resilience in marine ecosystems. The reintroduction of sea otters to Southeast Alaska following their extermination in the 19th century fur trade provides an opportunity to study the structure of marine ecosystems along a gradient of occupation of a top-level predator. The expansion of sea otter populations in Southeast Alaska has negatively impacted commercial, sport and subsistence shellfish fisheries, but it is possible that sea otter colonization may benefit other fisheries because otters promote a diverse kelp-dominated ecosystem. Fishery species that rely on kelp for spawning, nursery or adult habitat might be expected to benefit from sea otters. Ecological theory predicts that systems with top-level predators are more stable than those with top-level predators removed. We will investigate these processes by collecting ecological data using SCUBA survey techniques to study the effects of sea otter recolonization (no otters, recently colonized <2 years, established <10 years and established >20 years) on kelp, fish and invertebrates communities throughout Southeast Alaska. Our interdisciplinary study will include local and traditional knowledge through semi-directed interviews on the abundance, distribution, and impacts of sea otter recolonization. Ultimately, our goal is to use input values drawn from resource users and stakeholders as well as analytical information from statistical analyses and conceptual models to estimate the current location, amount, and value of otter-mediated kelp forest ecosystem services and tradeoffs under different management alternatives.

Long-term monitoring of coastal rocky beaches in Kachemak Bay

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This project is part of the new Long Term Monitoring initiative (EVOSTC) but is based on ongoing monitoring efforts in Kachemak Bay since 2003 as part of the Census of Marine Life (CoML) Program. With continued changes in climatic and hydrographic conditions, long-term monitoring is a tool to detect early changes in rocky intertidal communities. Here we present a first analysis of intertidal rocky communities in Kachemak Bay between 2003 and 2012, based on percent cover data at various tidal strata. Depending on tidal stratum, community differences among sites were more pronounced than differences among years, although temporal differences existed at each site. For the new LTM initiative, we are now also adding monitoring of mussel beds, an important food source for higher trophic levels and bioaccumulators, and of seagrass beds.

Joint effort adds 24th year to longterm rocky intertidal photo-monitoring of western Prince William Sound

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For the 24th consecutive year the author and five collaborators completed landscape-scale photography of nine longterm rocky intertidal monitoring sites in Western Prince William Sound during late May through early August, 2012. The photo sites include two unoiled locations, two previously oiled but not cleaned “set asides”, four oiled and high-pressure and hot-water treated sites and a 2000 landslide site, each with two or more photo points (total 19). A draft photo “job aid” was prepared and distributed to volunteers. Photos by collaborating partners were taken during their unrelated cruises and surveys; one site was visited by an educator in Crab Bay and two sites by the lead author during a one-day charter. Another collaborator took aerial images of a changing mussel bed on a tombolo in Upper Passage. Photos from one photo-point, “Mearns Rock” in Snug Harbor, were examined by five non-biologists to document variability in estimating percent cover. When compared to previous photos, the 2012 collection revealed that during the past decade there has been a general (region-wide) decline in seaweed cover, to about 2006, followed by a major increase in cover peaking in 2008-2010 depending on site, and then followed by what appeared to be a new decline in summer 2012. There was also a visibly significant mussel “set” in 2007 at several sites, with mussels taking up increasing percent cover until about 2010. At the tombolo (“Mussel Beach”) mussels began forming multi-layered masses after their near absence for 15 years. Over the past nearly quarter century the photos (and quantitative quadrat data during the 1990s) suggest there have been three “waves” of alternating heavy and light cover of seaweed (*Fucus* sp.), mussels and possibly barnacles, with periods of 4 to 7 years. We hope this low-cost, rapid, annual collaborative photo survey can be continue into the future, and expanded, thus establishing the range of natural variability in the rocky intertidal of Western Prince William Sound, variability which could be affected by changing climatology, other catastrophic events such as earthquakes and oil spills and general nearshore productivity. Collaboration may be an effective mechanism for continued surveillance.

Epidemiology: An emerging research tool for marine science and conservation

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Epidemiology is the study of the occurrence of disease and health-related conditions in populations of individuals relative to their environment and demographics. This relatively nascent discipline in marine research may be useful to marine scientists and managers in a variety of ways including identifying environmental, anthropogenic and demographic risk factors for specific diseases of marine life, developing population health metrics and reports of surveyed populations, hypothesis generation and testing, and long term risk assessments. Specific examples of epidemiology applied in the marine field include the identification of environmental and anthropogenic risk factors for leptospirosis in California sea lions (*Zalophus californianus*), analyzing and comparing health and life history metrics between healthy Bristol Bay and endangered Cook Inlet belugas (*Delphinapterus leucas*), modeling the impact of contaminants and decreased energetics in cetacean population projections, and identifying and monitoring of terrestrial-source pathogens that may negatively impact marine ecosystems. Other potential applications include conducting trend analyses and interpretations of retrospective data collected from surveys and long-term monitoring projects, identification of factors that increase the risk of fishery interactions, and analyzing other human-related impacts to marine species. Epidemiology has an important role in observing contemporary impacts from climate, humans, and other processes for their impact on the health and survival of marine species and their environment. It affords a method to assess the quality of data sets within analyses, identifying data needs and limitations, and recommendations for further data collection. It can also describe the relative size and nature of problems that necessitate more thorough investigation, offer a metric for comparison between populations in order to quantify the effects of various stressors on life history metrics such as fecundity and survival, and a means to analyze a number of desperate data sets of varying quality to quantify effects and test hypotheses. This set of tools can ultimately help marine scientists and resource managers standardize prioritization of research needs, evaluate risk factors for priority concerns, and translate science into policy and management.

Seasonal nearshore fish sampling in the Gulf of Alaska using a small purse seine

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As part of the Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP), we sampled fish in nearshore areas within nine bays in the eastern and western sides of the GOA. The bays varied widely in their geographical extent, predominant habitats, and exposure to offshore waters. Sampling was conducted during April, July, and September in the eastern GOA and May, August, and October in the western GOA. We used a 16 ft inflatable boat to deploy a ~15 m diameter purse seine, pursing and retrieving the net by hand. Sampling was limited to depths of 20 ft and shallower to ensure that the lower edge of the net contacted the bottom. Sampling sites were also chosen based on the presence of vegetative physical structure attached to the seafloor (e.g., eelgrass, *Laminaria* kelp) as identified using a skiff-mounted echosounder and visual observation. At each sampling site we measured temperature and salinity, and when possible we deployed an underwater video camera to verify habitat type. Results presented in this poster are preliminary, as the work will be repeated in 2013 and interannual variability will alter our interpretation of the data. The species composition of and abundance in catches varied within and among the sites, as well as with season. For all areas, species composition changed more dramatically from spring to summer than from summer to fall. Age-zero Pacific cod and pollock were abundant in summer catches in the western GOA, and to a lesser extent in eastern GOA summer catches and gulfwide fall catches. Juvenile rockfish were encountered more frequently in the eastern GOA. While some species appeared to have a strong preference for one type of vegetative habitat, the distribution of juvenile fishes seemed to be less dependent on small-scale habitat features and more influenced by large-scale geographic patterns within bays. Abundance of fishes was greater in the western GOA. The results of these studies will be used to investigate fish ecology within bays and will also be combined with offshore studies conducted simultaneously to understand connectivity between inshore and offshore areas of the GOA.

Small-scale oceanography of the inshore Gulf of Alaska

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Through our participation in the Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP), we are conducting extensive oceanography research of inshore waters of Alaska. This research focuses on eleven sites on the eastern and western sides of the GOA: nine bays and two island areas that are known seabird breeding sites. The bays vary widely in their geographical extent, degree and type of freshwater influence, exposure to offshore waters, and other environmental factors. Sampling is performed during three seasons: March/April, July/August, and September/October. We completed one full year of sampling in 2011 and will repeat the effort in 2013. The work consists of sampling a number of closely-spaced oceanography stations at each site, coordinated with fish surveys using multiple gears. At each oceanography station we deploy a Seabird 19+ instrument package that measures depth, temperature, salinity, turbidity, and dissolved oxygen continuously throughout the water column to within 5 meters of the seafloor. We also perform a vertical zooplankton tow using a 1 m ring net; this sample is also used to identify any ichthyoplankton encountered at inshore sites. We use a surface water sampler and a hand-deployed Niskin bottle to take water samples at 0 m and 20 m depth to measure nutrients and chlorophyll. Preliminary results, presented in this poster, display a high degree of spatial variability in water column characteristics within and among the inshore sites. There is also seasonal variability in these characteristics. The results will be used to describe environmental conditions for fish and other life forms, and also to study connectivity among inshore and offshore regions.

Ballast water management practices among the coastwise tanker trade in south-central Alaska

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Ballast water is a well-known and significant transfer vector of non-indigenous and invasive species, particularly among intra-coastal ports. Short voyage durations are associated with high survival rates of organisms and environmental similarity between ports has a positive effect on organism's ability to survive once discharged. Vessel ballast water management (BWM) is therefore critical to reducing the spread of non-indigenous and invasive species especially between intra-coastal ports. BWM refers to the practice of minimizing the number of aquatic non-indigenous species transferred by ships' movements and may include forms of water treatment or exchange. The aims of this research were 1) to identify patterns of tanker arrivals and BWM practices in Valdez, Nikiski, and the Drift River Oil Terminal, Alaska and 2) to quantify change in BWM practices based on volume of water discharged per method of management and per source port in Port Valdez. Data analyzed from the National Ballast Information Clearinghouse reveal an annual average of 5.9 million metric tons of ballast water was discharged into Port Valdez between 2004 and 2011. Evolution of BWM was apparent during this time as regulations took effect for previously exempted tankers involved in coastwise trade. For managed vessels, BWM preferences were evident as tankers more often chose a flow-through method (70%) rather than an empty-refill method (30%). This study describes tanker traffic patterns in south-central Alaska, quantifies the magnitude of intra-coastal ballast water transport, and documents the evolution of BWM in Port Valdez.

Red flags or red herrings? Using ecosystem indicators to detect anomalous conditions in the Gulf of Alaska in 2011

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NOAA compiles and synthesizes information about the Alaska marine ecosystem annually into an ecosystem considerations report primarily for the North Pacific Fisheries Management Council, but also the scientific community and the public. The goal of this report is to provide stronger links between ecosystem research and fishery management and to spur new understanding of the connections between ecosystem components by bringing together many diverse research efforts into one document. There are more than one hundred time series of physical and biological indicators that are tracked and updated, many annually. The status and trends of these indicators are monitored for early signals of ecosystem change that may have management implications. Several lines of evidence from indicators ranging from physical to upper trophic suggest that there were anomalous conditions in the Gulf of Alaska during 2011 and that these conditions were influenced by bottom-up forcing. The first indications were noted in upper trophic organisms (forage fish eating seabirds and Pacific halibut) that experienced reproductive failures and potential nutrient deficiencies, respectively. Abundance indices of plankton and forage fish, halibut stomach contents, and ocean surface currents also indicate anomalous conditions occurred during 2011. In this study, we compare multiple lines of evidence that suggest that changes in bottom-up forcing factors negatively influenced productivity at the lower trophic level that in turn negatively influenced, and were detectable in, upper trophic organisms.

Gulf of Alaska - Humans

NOAA's Teacher in the Lab Program: Making research and maritime careers accessible to all students

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We expanded the "Teacher in the Lab Program" into a curriculum designed to expose high school students to careers in science and maritime industries. While most extracurricular science activities are typically geared towards advanced and highly motivated students, we focused on working with the CHOICE Program (Choosing Healthy Options in Cooperative Education), a program for "at risk" students at Juneau-Douglas High School in Juneau, Alaska. The National Oceanic and Atmospheric Association (NOAA) Teacher in the Lab pilot program is a teacher research experience where teachers and NOAA scientists collaborate to conduct lab exercises, experiments, and activities to enable teachers to learn more about the laboratory environment and research projects. We added a student component, in which the teacher's connections with researchers are passed on to the students. Students participated in classroom and field components, and had the opportunity to tour the fishing vessel Epic Explorer that was chartered by NOAA to conduct research. Students experienced life on board a research vessel chartered by NOAA. Both the crew of the Epic Explorer and NOAA scientists shared their knowledge and experiences with students. Students collected zooplankton and worked to key out species they caught. Our curriculum was geared towards a maritime community; however, this approach of combining industry and science could be easily modified for other regions to demonstrate the practical side of science and math to a broad spectrum of students.

Winners and losers in the commercial fisheries catch share debate: Pacific halibut and Baltic cod

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Catch share management programs for commercial fisheries are sweeping the world's oceans, with varying results. The Alaskan halibut (*Hippoglossus stenolepis*) commercial fishery has been managed through an individual fisheries quota (IFQ) system since 1995. Proposed reforms to the European Union Common Fisheries Policy (EU CFP) will institute an individual tranferrable (fishing) concessions (ITC) regime for Baltic Sea cod (*Gadus morhua*) in 2014. IFQ and ITC are very similar, but the Pacific Ocean and the Baltic Sea are not. Can similar management strategies work in drastically different ecosystems? In varying societies and economies? By combining previous research with new data, I will attempt to answer these questions. Previous work: Baltic Sea fisheries are currently governed by the EU CFP through a number of multi-level, interwoven schemes. A key part of the EU CFP is the ecosystem approach to fisheries (EAF). EAF calls for a focus on the human dimensions of fisheries ecosystems. In line with this approach, the EU CFP calls for increased participation by stakeholders at regional and local levels. In Poland, this goal is pursued through the creation of new arenas, such as Fisheries Local Action Groups (FLAGs), stakeholder forums (such as the WWF hosted Round Table meetings), and fish Producer Organizations (POs). My work analyzes the creation of these stakeholder arenas from the perspective of Small-Scale Polish Fishers. I was especially interested in determining whether the participation of Small-Scale Fishers—traditionally a group with a low level of Successful Stakeholder Participation (SP)—changed, and how. Fieldwork included two months of bilingual interviewing and visits to 46 communities along the Polish coastline. I spoke with Fishers, scientists, environmental activists, and community members in order to create a comprehensive outline of the current Polish fishing fleet. I found that a lack of transparency and efficiency in the EU CFP system prevents the voices of Small-Scale Fishers as Stakeholders from being heard in effective ways. New stakeholder arenas have been unsuccessful in creating space for new participants and instead perpetuate old hierarchies of agency in the policy system.

Gulf of Alaska - Humans

2012 Alaska marine debris surveys

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The National Marine Fisheries Service sampled derelict fishing gear and other plastic debris on beaches in Alaska periodically from 1972 to 2008 and again in 2012. In 2012 survey, additional beach segments were added to encompass eastern Gulf of Alaska coast from Dixon Entrance west to Chirikof Island. Overall, 87 beach segments were sampled for the presence of anthropogenic marine debris. Here I present the findings from the 2012 surveys and compare the trends in abundance and composition of marine debris on Alaskan shores to what was historically found. In addition I address the presence of marine debris from the 2011 Japanese tsunami in relation to these trends.

Japan tsunami debris – Information and actions

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On March 11, 2011, a devastating 9.0 earthquake and tsunami struck Japan. The disaster claimed nearly 16,000 lives, injured 6,000, and destroyed or damaged countless buildings. As a result of the disaster, NOAA expects a portion of the debris that the tsunami washed into the ocean to reach U.S. and Canadian shores over the next several years. NOAA is leading efforts with federal, state, and local partners to collect data, assess the debris, and reduce possible impacts to our natural resources and coastal communities. The Government of Japan estimates that 5 million tons of debris was swept into the Pacific Ocean, about 70 percent sank right away, and 1.5 million tons floated off the coast. There are confirmed reports of tsunami debris having already reached the coasts of Alaska. This debris is composed of materials found in urban areas, including bottles, jugs, Styrofoam, building fragments, boats, plastics, wood, docks, ropes, buoys and other items. This poster will discuss the state of knowledge and potential actions on tsunami debris distribution, movement, impacts, and actions. It will also include a basic introduction to the issue, and then a discussion on data needs and potential opportunistic and targeted methods to fill those needs.

Gulf of Alaska - Humans

Paralytic shellfish poisoning: Preparation of monoclonal antibodies to saxitoxins for use in PSP detection

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Paralytic shellfish poisoning (PSP) is caused by the consumption of shellfish contaminated with saxitoxins (STX). PSP continues to be a deadly public health threat in Alaska due to the unpredictable occurrence and variation in concentration of STX in Alaskan waters. Current methods to monitor PSP toxins in Alaska are hampered by costly and time consuming analytical techniques. We report the development of novel enzyme-linked immunoassay reagents useful for constructing rapid, accurate, and inexpensive tests to detect STX and STX congeners. The sensitivity and specificity of two prototype PSP assays has been characterized and a method for extraction and detection of STX in shellfish was demonstrated. Two formats for STX detection were employed. One method uses a flow-through membrane assay format to provide a simple, rapid result that can be performed in the field and detects toxic levels of STX qualitatively. The second uses a microtiterplate format for rapid quantitation of STX and is designed for testing large numbers of samples in a laboratory setting. Both methods are described and representative results presented. Plans to improve the techniques and develop commercially available products are discussed.

Statistical analysis of freshwater discharge into the Gulf of Alaska

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Regression equations for mean monthly streamflow in watersheds running off into the Gulf of Alaska have been determined. The equations were obtained by regressing observed streamflow at 246 USGS and Environment Canada gaging stations against a number of relevant meteorological and basin physical parameters. Meteorological parameters include mean monthly precipitation, cumulative water year precipitation, and mean monthly temperature. High-resolution grids of these parameters were obtained through statistical downscaling methods. Basin physical parameters include area, mean elevation, and percent forest cover, and were selected from a larger set based upon initial regression efforts. Regionalization was used in order to organize the entire ensemble of gaged watersheds into several hydrologically similar groups. When comparing regression-calculated flow to measured flow the groups showed typical average errors of 40%, a value consistent with previously obtained equations for other runoff quantities such as peak flows. Once the regression equations were finalized, they were applied to a set of ungaged watersheds making up the entire Gulf of Alaska drainage. This yields predictions of freshwater runoff to the Gulf, with 1 square kilometer spatial resolution and monthly temporal resolution.

State of the Sound: Trends in the oceanography of Prince William Sound

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The ecosystems of the PWS region are influenced in part by bottom-up environmental factors: lower trophic levels are generally ectothermic, and metabolic and other vital rates are temperature controlled. More importantly, the amount of production that occurs in the water column is ultimately limited by the amount of nitrogen that annually becomes available to primary producers. The amount of available nitrogen is influenced by vertical stability (i.e., the onset of a seasonal thermocline or halocline) and mixing processes (e.g., storm mixing and wind driven upwelling). Superimposed over all those changes in the physical environment are myriad changes in the marine ecosystem, both in terms of the constituents (who is there) and abundance (how many there are, or their biomass). The phenology of ecosystem components (the timing of who appears) is also important, particularly with regards to matches and mismatches between predators and prey and is likely driven in part by temperature. The PWS region has been infrequently surveyed since the mid 1970s, with the most temporal coverage during the years immediately following the Exxon Valdez Oil Spill in 1989 and during ongoing PWS herring survey efforts which began in 2009. It can be expected that the hydrology of the region is changing: local warming has lead to the recession of ice mass in the region, with an expected concomitant change in the timing and magnitude of freshwater and heat fluxes from the land and atmosphere to the ocean. Comparison of current observations to those from the data record from earlier surveys suggests that the timing and magnitude of the annual temperature peak in the surface layer has changed in recent years. The signal in surface salinity is much more variable and patterns are more subtle, but there is the indication of a freshening trend in autumn/winter in recent years.

Carbonate cycling in a north temperate fjord

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Annual change in pH, total alkalinity (TA), and total dissolved inorganic carbon (TC) is about ten times greater in coastal Gulf of Alaska water than in the open ocean and varies as much or more within a single year than the global 0.6 pH change observed in the past 200 years. Potential candidates for controlling seasonal carbon change in coastal waters include atmospheric carbon dioxide levels, the annual solar cycle, which drives global thermal and moisture cycles, and shoaling of deep sea corrosive water. Of these, the hydrological cycle, specifically terrestrial runoff, is the most parsimonious explanation for high amplitude pH change in coastal water. Consistent with this inference, amplitude decreases with depth where there is less freshwater influence and toward the open ocean. In theory, any one of the three measured carbon parameters can be calculated from the other two but apparently another factor, phytoplankton productivity, influences pH differently (or more rapidly) than the other two parameters, hence primary productivity also has a discernible influence on annual carbon cycling. The pH values are highest in spring-summer and lowest in winter; TA, TC, and salinity patterns are the opposite. Large annual change implies that indigenous coastal marine fauna are likely adapted to this cycle, and hence may be relatively resistant to slow global trends downward in oceanic pH.

Temporal variation in the physical properties of four fjords in Prince William Sound, Alaska used as nursery habitat by juvenile Pacific herring (*Clupea pallasi*)

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From March 2010 to May 2012 the physical properties within four fjords in Prince William Sound, Alaska, were monitored using oceanographic moorings. The four sites include Simpson Bay, Zaikof Bay, Eaglek Bay and Whale Bay, all of which were the focus of herring research during the Sound Ecosystem Assessment (SEA) program from 1994 to 1998. All sites showed a similar general response to the annual meteorology, with the warmest surface conditions occurring in the summer of 2011 (15-17.5 °C) and the coolest conditions in the summer of 2010 (13.5-14.5°C). In winter the surface water gradually cooled between years, and minimum surface temperatures ranged from 3 to 4.25°C in 2010 and 0.25 to 2.5°C in 2012. Just as during SEA, however, the magnitude of summer heating and freshening varied significantly among locations at frequencies shown in power spectra ranging from fortnightly to semidiurnal tides and higher frequencies likely corresponding to diurnal winds. The power (i.e., variance) of TS properties was also tracked over time using wavelet analysis, and all sites showed statistically significant spectra ($p < 0.05$) for periods of 2 to 16 hrs and 32 hrs and higher. Variance at the above periods was strongest in the summer of 2011 and weakest in the winter of 2010/2011. In both summers all sites exhibited significant power at longer periods of 128 to 256 hrs corresponding to either aperiodic wind events, such as storms, or periodic forcing by fortnightly tides. However, individual fjords also exhibited unique temporal patterns in spectral power at various periods. For example, Whale Bay had significant power focused in the 6 to 8 hr band for both variables, whereas the other locations all had significant power in temperature or salinity in either year, that was spread more evenly among time scales. The latter results, along with marked differences in integral time scales both among and within locations each year, suggest that there is marked uncertainty in predicting the physical properties of certain fjords from proxy locations such as NOAA weather buoys and tide stations or PWSAQ COOP stations.

Gulf of Alaska - Climate and Oceanography

Comparison of 1964 earthquake-triggered submarine landslides near Whittier and other Alaskan fjords from new multibeam and seismic imaging

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The 1964 Alaska M9.2 earthquake triggered numerous submarine slope failures in fjords along the southern Alaska margin. These failures generated local tsunamis, which caused many more fatalities than other effects of the earthquake. The 1964 earthquake triggered tsunamis that inundated the town of Whittier in three waves that hit within 4 minutes of the beginning of shaking. Run up reached 12 m in the town and 25 m across the bay, with 13 casualties. We collected new multibeam bathymetry and sparker seismic data in Passage Canal, Alaska, to better map the location and characteristics of the 1964 and earlier submarine landslides. The new bathymetry reveals the debris field from the 1964 submarine landslide, which covers the western 5 km of the fjord bottom. Individual debris blocks are up to 145-m across and 25-m tall. Mapping the debris lobes based on the seismic data and seafloor geomorphology indicates all mass transfer deposits originated from the fjord head delta, not from rockfall from the fjord walls. The seismic reflection data show the 1964 deposit having an average thickness of 6 m and a volume of 20 million cubic meters. We were unable to identify pre-1964 failures, despite imaging fjord sediments to more than 75 m below the bottom. Features of 1964 submarine landslides in three fjords (Passage Canal, Port Valdez, and Resurrection Bay) show both similarities and considerable differences. All involved failure of fjord-head deltas with deposition of mass transfer deposits in the flat fjord bottom. All had erosive failures that entrained sediment as they travelled. All fjord head failures involved blocks, but the amount of blocky material and the distance it traveled varied greatly. Lastly, Port Valdez, Passage Canal, and possibly Resurrection Bay, were strongly influenced by increased sediment brought to the margins of the fjords during the neoglacial period between the 1964 and the penultimate earthquake around 900 years ago. This increased sediment supply may have caused the 1964 earthquake to produce particularly numerous and large submarine landslides.

A model-based examination of multivariate physical modes in the eastern and western Gulf of Alaska

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The Gulf of Alaska (GOA) supports major marine resources, and is governed by unique physical dynamics which include substantial tidal mixing, strong eastern and western boundary currents, seasonal downwelling circulation, along-canyon transport, and intermittent cross-shelf transport by eddies. Using multivariate EOF analysis, we have examined a suite of physical variables from circulation model output (wind stress, temperature, salinity, mixing, surface heat fluxes) to determine how these co-vary and to what extent we can summarize the combined physical state of the GOA using a limited set of spatial/temporal patterns. We also examine the correlation of large-scale atmospheric/oceanic patterns (PDO, ENSO, NPGO) to multivariate patterns of the GOA. These analyses indicate that El Niño (as described by the Multivariate ENSO Index, MEI) is a dominant contributor to variability of the region as a whole, being strongly correlated with the leading multivariate mode of the GOA. El Niño years correspond to stronger northeastward wind stress, stronger Alaskan Gyre circulation, higher coastal sea level, warmer sea surface temperatures, a deeper coastal mixed layer, enhanced shortwave radiation, and enhanced sensible heat losses. When the eastern and western sides of the Gulf are analyzed separately, the North Pacific Gyre Oscillation (NPGO) is found to be significantly correlated with the leading multivariate mode of the eastern GOA. This leading mode contains higher near-coastal sea surface height and stronger coastal flows in association with intensified northwestward wind stress, but unlike the leading mode of the full GOA, has no significant SST component.

Seward sea level variability: Sources and implications

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Coastal sea level variability is associated with meteorological and oceanographic forcing. The main focus of our work is to determine the subtidal response of sea level to atmospheric and oceanographic forcing. We examine these influences using estimates of winds and sea level pressure from National Center for Environmental Prediction atmospheric forecast models and oceanographic data obtained from a long-term mooring at hydrographic station GAK 1 at the mouth of Resurrection Bay. Both the wind and mooring data form nearly coincidental and continuous data sets spanning the time period of 2000 to 2011. We use 30 years of sea level data measured at Seward, Alaska to examine sources of variability. Tides dominant the variability at short periods (≤ 24 hours) and account for 97% of the total sea level variance. The remainder of the variability is due to atmospheric forcing. The inverted barometer effect (IBE) accounts for an additional 2% of the sea level variance. However, the IBE influence is not uniformly distributed across the spectrum; it accounts for ~70%, 90%, and 40% at periods of 2, 8, and 14 days, respectively. The along-shore wind stress component accounts for 20 – 60% of the sea level variance in summer (April - September) for periods from 2 to 20 days. In winter, stronger along-shore wind stresses account for 50-80% of the variance over the period band of 2 – 100 days. We constructed time series of geopotential height from the GAK 1 moored data. The annual cycle (amplitude and phase) of the GAK 1 dynamic height corresponds closely to that of Seward sea level in most years, with the maximum in both occurring in October-November, coincident with the annual maximum in coastal freshwater discharge. In 8 of the 10 years examined, the phase differences are < 2 weeks, suggesting that thermosteric forcing dominates sea level variability at the annual period. However, in 2 of the years examined the phase difference between the two annual signals is ~50 days. The reasons for this difference are not apparent but likely due to the combined influences of wind and freshwater forcing.

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NPLCC Science/Traditional Ecological Knowledge Strategy: What to do when you can't do it all

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The North Pacific Landscape Conservation Cooperative (NPLCC) is part of a network of 22 LCCs (5 are in Alaska) that provide a forum for U.S., Canadian, and Mexican governments; Tribes and First Nations; universities; non-governmental organizations and other conservation partnerships and entities to work together across their boundaries in a new way. LCCs are self-guided partnerships. The mission of the NPLCC is to promote development, coordination and dissemination of science to inform landscape level conservation and sustainable resource management in the face of a changing climate and related stressors. The NPLCC encompasses approximately 204,000 mi^2 (530,000 km^2) extending from southcentral Alaska to northwestern California, including parts of four western U.S. states, one Canadian province and one Canadian territory. The coastal temperate rainforests within this unique ecosystem are among the last remaining intact forests of their kind in the world. The landscape is characterized by interconnected marine, freshwater, and terrestrial ecosystems that are all impacted by climate change. Established in 2001, the Steering Committee adopted a Charter with the LCC's structure (http://www.fws.gov// NPLCC). The Science/Traditional Ecological Knowledge (TEK) Subcommittee was charged with developing the NPLCC's four-year Science-TEK Strategy (Strategy). The Strategy seeks to "maximize the availability of partners, constituents, and stakeholders to make informed conservation and sustainable resource management decisions in the face of climate change and related stressors." In developing the Strategy, a number of actions were undertaken to identify potential areas of focus for the NPLCC. To screen the long list of potential topics, an "Impact Matrix" with pairings of climate-related drivers and valued cultural and natural resources was used. After applying evaluation criteria to the top ranked topics, five Priority Topics were selected to include in the Strategy. Additionally, a set of four Guiding Principles were identified to ensure the Strategy is balanced and meets the needs of all the NPLCC partners and stakeholders. This Strategy will drive the NPLCC's annual implementation planning process and will be used to work with partners where their work is consistent with the NPLCC mission.

Introducing the Marine Particle Dynamics Laboratory at the University of Alaska Fairbanks

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As a new Assistant Professor of Oceanography in the School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks, I am actively building my research laboratory to study particles in the ocean, with a focus on Alaska's marine environment. In this poster, I introduce my laboratory's research directions, capabilities, planned projects, and potential collaborations. My research focuses on assessing the biogeochemical role of various particle processes such as particle formation, sinking, lateral transport and remineralization. These processes have important implications for regional and global carbon budgets, the manifestation of ocean acidification, the supply of organic material to subsurface ecosystems in the water column and on the sea floor, the balance of carbon dioxide between the ocean and the atmosphere, the distribution of elements throughout the oceans and sediments, and the fate of pollutants such as oil in the marine environment. To address these research topics, my laboratory utilizes and develops a variety of oceanographic sampling and analysis techniques including bulk sediment traps, polyacrylamide gel traps, in situ photography, particle filtration, and in situ particle incubations. These tools enable the assessment of the magnitude and composition of particle fluxes and composition, the particle size distribution, the average sinking velocities of particles in the water column, and the rates of particle decomposition through microbial respiration. In addition to this oceanographic observational work, I also use numerical models of ocean circulation and biogeochemistry to investigate the combined effects of particle export, sinking, lateral transport, and remineralization. I plan to employ these methods in Alaskan waters and throughout the global ocean.

The dynamic controls on carbonate mineral saturation states in a glacially dominated estuary: Glacier Bay, Alaska

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Numerous studies have shown that the intrusion of anthropogenic CO^2 into the ocean has created an acidification phenomenon. However, the uptake of atmospheric CO^2 is not the only climate-induced factor that leads to a reduction in marine pH and suppression of carbonate mineral saturation states (Ω). Over the past 250 years Glacier Bay, AK has experienced rapid deglaciation leading to an increase in the amount of freshwater entering the marine ecosystem. This surge of low-alkalinity glacial runoff is expected to reduce the buffering capacity of surface waters and enhance the vulnerability of the estuary to further changes in pH. This increased vulnerability and suppression of Ω provides the potential for these waters to become harmful to some organisms with unknown consequences to higher trophic levels. Monthly sampling has shown that seasonal undersaturations with respect to aragonite occur bay-wide, beginning in the upper arms during summer and then move south into Icy Strait and Cross Sound later in the year. Here, we present results from a year-long study that was designed to better understand the effects of freshwater from glacial sources on the marine carbonate chemistry and constrain the current extent of ocean acidification in this pristine estuarine environment.

Iron and related parameters along the Gulf of Alaska shelf in 2011

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The Gulf of Alaska is a region with contrasting ecosystems where the availability of the essential micronutrient iron (Fe) contributes to the observed productivity. NPRB's Gulf of Alaska Ecosystem Research Project (GOAERP) investigates interconnections among various trophic levels of this important region. As part of GOAERP lower trophic level component, the distribution of Fe over the Southeast GOA shelf was investigated during the spring of 2011, and along the GAK line (Western GOA) during the fall of 2011. Iron-binding organic ligand information was also obtained from surface water samples during both seasons, and the photosynthetic efficiency of phytoplankton was determined along the GAK line. During May 2011, shelf inputs of iron were apparent on depth profiles, and surface dissolved Fe ranged from 0.28 nM offshore to 4.5 nM near Kayak Island, with an average concentration of 1.23 nM. Reactive Fe was elevated with dissolved Fe making on average only about 20% of the reactive Fe pool. Along the GAK line surface dissolved Fe concentrations decreased rapidly from inshore (4.87 nM) to offshore (0.052 nM), and showed daily variability. The contribution of dissolved Fe to the reactive Fe pool was generally <5%, but increased to 28% at the furthest offshore station. The maximum photochemical efficiency (Fv/Fm) in surface waters tended to decrease from nearshore to offshore, with the lowest value found at GAK 13 where chlorophyll concentration was low (~0.5 ug Chl/L) and dissolved inorganic nitrogen was relatively high (~ 10 uM). Within the photic zone, the Fv/Fm tended to increase with depth. At both locations, iron binding organic ligands were in excess of dissolved Fe, and both ligand classes observed (L1 and L2) had high stability constants, indicating that dissolved Fe was strongly bound, and suggesting ligand production.

Effect of oceanographic conditions on toxic *Alexandrium fundyense* abundance in Kachemak Bay, Alaska

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Paralytic Shellfish Poisoning (PSP), a chronic health problem in Alaska, results in lost shellfish revenues exceeding $10 million annually. PSP occurs after organisms consume molluscs and crustaceans tainted with neurotoxins (saxitoxins) produced by toxic microalgae in the genus *Alexandrium*. Previous work demonstrated that *Alexandrium fundyense* is the predominant saxitoxin producing species in Alaskan coastal waters. The goal of this study was to determine what oceanographic conditions favor *A. fundyense* growth in Kachemak Bay (KB), Alaska, a region with important commercial and recreational shellfish industries. Establishing which conditions encourage bloom formation will help public health officials, resource managers, and commercial aquaculture facilities better monitor for PSP outbreaks. Water column temperature-salinity profiles were collected from May to September 2012 at stations throughout KB and used to determine vertical stratification in the upper water column. Stratified conditions were present at most stations throughout the season, reflecting a significant freshwater influence on water column stability. Tidal elevation data were obtained from a NOAA tidal gauge in Seldovia, AK. Corresponding surface and water column phytoplankton samples were collected, returned to the laboratory and filtered. *A. fundyense* concentrations were estimated by extracting DNA from filters and performing species-specific quantitative polymerase chain reaction assays (qPCR). Low concentrations of *A. fundyense* were found at all sampling locations throughout the season with some sites showing elevated cell concentrations when water temperatures exceeded 10.5°C. *A. fundyense* concentrations were significantly correlated with both water temperature and mesohaline (24-29 PSU) conditions. Abundances were higher on ebb tides. These data indicate the even small increases in summertime water temperature associated with climate change will favor the growth of *A. fundyense* and increase the risk of PSP events. Future efforts will focus on resolving the environmental and hydrodynamic conditions that trigger *A. fundyense* blooms and incorporating those results into an ecological model of KB. The study results are currently being used to improve ongoing federal and state KB phytoplankton monitoring programs.

Physiological assessment of *Mytilus* spp. in Kenai Fjords National Park

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Global increases in pollution and changes in the climate are affecting environments worldwide. Blue mussels (*Mytilus* spp.) are often used as biological indicators of site health because they are ubiquitous, sessile filter-feeders that bioaccumulate environmental contaminants. However, mussels may be able to serve as indicators of other types of environmental change as well, including microbial pollution or change in water chemistry or temperature. In order to validate a panel of assays designed to assess the physiological health of blue mussels, a total of 160 *Mytilus* spp. were collected from five sites in the Kenai Fjords National Park during the summer of 2012. The study had three general objectives: first, we compared different transport conditions (on ice, in water) to establish guidelines to maintain a viable stock of mussels from distant sites to the laboratory. Second, we performed a series of experiments to establish baseline physiological and behavioral parameters. Our assay panel included hemocyte viability, DNA damage, immune function, byssal thread production, feeding rate, DNA:RNA ratio, condition factor, P450 activity, and heat shock protein levels. These particular assessments were chosen because each one detects physiological changes that occur for different environmental reasons, such as organic or inorganic pollution, general environmental stress, water acidification, or thermal stress. Finally, we determined whether the transport conditions influenced the results of the physiological assays. Mussels can be maintained on ice or in seawater from the mussel collection site for up to eight days, but mussels held in seawater had higher levels of survival and provided better material for the assays. The results from our study will provide methods to assess effects of environmental stress on blue mussels, a potential coastal indicator of environmental conditions and change.

Benthic habitat quality assessment on the Kenai Peninsula

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The NOAA National Status & Trends (NS&T) Bioeffects Program and the AK Dept. of Environmental Conservation (DEC) completed a characterization of sediment chemistry and benthic infaunal communities in the bays and fjords of Kachemak Bay and the Kenai Peninsula. Sediment was synoptically sampled in a stratified random statistical design in Halibut Cove, China Poot Bay, Sadie Cove, Tutka Bay, Kasitsna/Jakalof Bay, Seldovia Bay, and Koyuktolik Bay (Dogfish Bay). Port Graham Bay data from an earlier study was also included. In Chrome Bay the sampling plan included a transect leading away from a known heavy metals source from historical industrial mining operations, and included toxicity bioassays and tissue body burden assessment. Unexpectedly high PAH concentrations are found in Seldovia Harbor, but only marginally elevated away from the harbor. Levels of Cu, As, and Hg exceeded lower sediment quality guidelines (ERL) in selected locations due to local geology. Chromium and Ni exceeded the ERL in multiple locations and far exceeded the high guidelines (ERM) throughout Chrome Bay. Acutely toxic impacts were not observed however. Benthic community composition was driven by physical parameters and stressors (hypoxia, metals). Community makeup in Dogfish and Chrome Bay was distinct from the embayments in Kachemak Bay. Communities in several bays overlapped, while others were dominated by specific species assemblages.

Evaluation of the Abraxis Saxitoxin Enzyme-Linked Immunosorbent Assay for testing subsistence Alaska shellfish

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Alaska has a serious public health problem caused by paralytic shellfish toxin (PST) in shellfish consumed from personal and subsistence harvests. The testing of non-commercially harvested shellfish at the Alaska Department of Environmental Conservation (ADEC) Environmental Health Laboratory is not funded nor authorized to test for the safety of recreational or subsistence harvests. The best solution to protect public health is to utilize alternative testing methods that can be conducted in remote locations, require minimal training and are less expensive than the mouse bioassay. The ADEC has indicated the Abraxis Saxitoxin Enzyme-Linked Immunosorbent Assay (ELISA) for PST is a promising test that can reduce marine toxin testing from $125 to $15 per sample. The cost reduction and relative simplicity of using the ELISA could enable rural Alaska communities to develop PST monitoring programs. Randomly-collected Alaskan bivalve species (blue mussels, butter clams, Nuttallii cockles and Pacific littleneck clams) were dug at minus tides on Kodiak Island in July-August and on Annette Island in July-September. The shellfish have been frozen in the shell and this fall these will be thawed and the shellfish tissues homogenized. The non-commercial shellfish from the Southcentral and Southeast Alaska islands and representative commercial harvests of Pacific oysters and geoduck clams, sent directly to the ADEC from Southeast Alaska, will be tested using the ELISA at the Kodiak Seafood and Marine Science Center. We will ship acidified, filtered extracts prepared from composites of shellfish tissue homogenates to the ADEC Laboratory. In Anchorage, the laboratory technicians will use high performance liquid chromatography to validate the ELISA data and to provide an assessment of the PST analog compositions.

The Gulf of Alaska's salp bloom of 2011: Ignorance or harbinger of change?

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Salps are a pelagic tunicate capable of rapid and massive population explosions driven by asexual budding. During a bloom they may vacuum the water column of most other planktonic organisms. Like most zooplankton, salp species are characteristic of specific environments. Salps are also typically absent from the sub-arctic Pacific. The Gulf of Alaska program completed 3 broad-scale surveys from Southeast Alaska around the shelf to Kodiak in 2011 during which thumb-sized salps reached densities as high as several per cubic meter. They persisted over the entire sampling season, and some still remained in 2012. Densities were typically higher in southeast Alaska where we lack a good long-term observation basis, but even along the Seward Line they have only been observed over the last 15 years during the 2003 El Nino. Nonetheless, oceanographic conditions during 2011 were relatively typical of the Gulf. Do salps represent a periodic "random" wild card in the Gulf of Alaska ecosystem, or are they a signal of a changing and warming climate? We compare our observations with those from adjoining regions, in an attempt to distinguish between indicator and ignorance.

Phylogeography of species in the *Mazzaella oregona* clade (Gigartinaceae, Rhodophyta) in the northeast Pacific

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We examined genetic variation among isolates of species in the *Mazzaella oregona* clade: *M. oregona*, *M. parksii*, *M. phyllocarpa*, and *Mazzaella* sp. (this species has been described, but a new combination has yet to be made in *Mazzaella*) using the nuclear ribosomal ITS region, the chloroplast rbcL gene, and the mitochondrial COX1 "barcoding" gene. Based on our and published results, *Mazzaella oregona* is distributed from southern California to Kodiak Island, Alaska. There is little genetic variation in populations from California to Alaska except for a distinctive genotype found in individuals from the eastern Strait of Juan de Fuca in southern British Columbia and northern Washington and near Prince Rupert in northern BC. *Mazzaella parksii* is distributed from Mendocino Co., CA, westward to at least the westernmost Aleutian Island, Attu, Alaska. Populations show significant differentiation between southeastern populations (from southern Oregon to the Kodiak archipelago, Alaska) and northwestern populations (from the Kodiak archipelago to Attu Island, Alaska). *Mazzaella phyllocarpa* is recorded from Russia to Southeast Alaska and north to St. Lawrence Island in the northern Bering Sea. Although there is genetic variation among specimens from Alaska, there is no geographic pattern to this variation. *Mazzaella* sp. is distributed from the Commander Islands, Russia, to northern Vancouver Island, British Columbia. Although there is variation among individuals, there is little geographic pattern to this variation. These results resemble those found for other intertidal marine organisms in the northeast Pacific in that the high intertidal species showed the most phylogeographic differentiation, and a biogeographic break appears in the northwestern Gulf of Alaska for at least one of the species.

Development of biochemical measures of age in the Alaskan red king crab: Initial results and assessment

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Age determination of marine organisms is a central metric for understanding the timing and magnitude of spawning, recruitment and habitat use, juvenile duration, and population age structure. For commercially important *Paralithodes camtschaticus*, red king crab (RKC), size frequency analysis has been used in lieu of accurate age information for estimating population dynamics. Yet we know that crab growth is not a linear process, but typically a step function seen as intermittent molts of varied periodicity which leaves the estimation of age using carapace size alone highly variable. We are developing an alternative approach based on analysis of specific age pigments (lipofuscins) to assess RKC age to provide a more robust metric of age than size measurements alone. To validate the presence and utility of these biochemical markers, we used hatchery reared animals to investigate the suite of oxidation products produced and their accumulation in neural tissues of known age animals (0-4 years) reared in captivity. Results reveal that RKC show subtle differences in fluorescence properties of products compared to other crustacea previously examined with significant but slow rates of accumulation over the first 4 years of growth.

Development of *Mytilus* sp. bioindicators to monitor microbial water quality in marine environments

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In the marine environment, reduction in water quality relating to factors such as changing bathymetry, water circulation, water chemistry, contamination, or microbiology of the water may contribute to habitat loss. Coliforms have been widely used as indicator organisms of microbial water quality and laboratory methods are available for detection in environmental samples. However, in large water bodies and high dynamics, direct measurement of coliforms may pose challenges and accrue high cost. The focus of this study was to develop experimental tools to efficiently sample the environment to determine the degree of microbial water quality. We tested an experimental procedure using mussels (*Mytilus* sp.) as a bioindicator of fecal coliform presence and concentrations in the aquatic environment to develop and evaluate new tools for marine coastal habitat monitoring in large, dynamic water bodies such as Cook Inlet. We developed and refined a suite of experimental inoculation and testing methods, resulting in refined protocols to conduct the inoculations, process samples, and determine microbial concentrations in water and mussel tissue samples. Overall, the results indicate that *Mytilus* are capable of intake of coliforms from the surrounding waters. However, additional experimental work is needed to further evaluate and validate the use of *Mytilus* as an alternative method to monitor microbial levels in large, dynamic marine waters.

Seasonal patterns in nutrient acquisition, storage, and utilization by the California sea cucumber (*Parastichopus californicus*)

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The California sea cucumber, *Parastichopus californicus*, is a profitable Alaskan commercial export, as well as a vital subsistence food resource, and an ecologically important species that influences sediment carbon cycling. As a benthic deposit feeder, *P. californicus* depends on surface-derived food sources to fuel reproductive processes such as gametogenesis and spawning. Some lipids and proteins required for reproduction cannot be synthesized by marine invertebrates and must be acquired directly from food, and then potentially stored within tissues for use during food limited periods. Maternal investment in egg production is critical for survival of early life stages in invertebrates, particularly in free-spawning planktotrophic organisms such as *Parastichopus californicus*. Thus, many invertebrates undergo biochemical changes in body tissues over the course of the reproductive cycle that are associated with temporal changes in food supplies. During winter months, *Parastichopus californicus* are thought to cease feeding, and undergo an annual re-absorption of the viscera. In spring, gonad development begins, followed by broadcast spawning in mid-summer months. Here we assess seasonal patterns in diet, and nutrient storage and utilization in in situ populations of *P. californicus* from Southeastern Alaska. There were five collections, roughly two months apart, of adult *P. californicus* using SCUBA roaming diver surveys in order to correspond with what was expected to be the beginning of the five stages of oogenesis (e.g.. post-spawning, recovery, growth, advanced growth, and mature/spawning). Seasonal patterns in feeding behavior and diet were measured through total gut content mass and microscopic identification of remains. Preliminary data shows seasonal differences in gut content, where clams were found in late winter and silt/phytodetritus in spring. Nutrient storage and utilization were measured through a series of biochemical measurements (i.e., total protein and total lipid) conducted on gonad, muscle, viscera, and skin tissues. Results from this on-going study further our understanding of factors affecting reproductive fitness in benthic deposit feeders and has the potential to improve management of this lucrative Alaskan sea cucumber fishery.

Gulf of Alaska - Fish and Fish Habitat

Detecting long-term changes in forage fish populations in Prince William Sound, Alaska

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Fluctuations in the availability of forage fish may have dramatic ecosystem effects because much of the energy transferred from lower to higher trophic levels passes through a small number of key forage species. In Prince William Sound, the lack of time series data on abundance, distribution, and age structure of important forage species (e.g., Pacific sand lance, capelin, eulachon and krill) make it difficult to assess population status and trends of most forage species. As part of Exxon Valdez Oil Spill Trustee Council's Gulf Watch Alaska Long-Term Monitoring Program, we implemented a program in 2012 that aims to build a long-term forage fish dataset with the following components: 1) forage fish abundance, distribution, and community composition using a combination of hydroacoustic surveys and net-sampling methods, 2) indices of forage fish biology and population dynamics, including growth and age-at-length; and, 3) physical and biological variables in the environment that may affect fish distribution and population dynamics. In July 2012 we conducted over 600 km of hydroacoustic surveys, and counted marine birds and mammals along the way. We ground-truthed acoustic signals and assessed forage species community composition with 31 midwater trawl sets at 27 sites. At each trawl site we also measured oceanographic characteristics and sampled zooplankton. We targeted Pacific sand lance with 20 beach seines at 12 sites. Overall, young of the year walleye pollock were the most numerous and frequently encountered species, followed by Pacific herring. Capelin, eulachon and euphausiids were collected more infrequently, and they occurred mainly in the cool, turbid waters of the fjords. We collected at least three age classes of sand lance in nearshore waters. Over time we expect to detect changes in populations and better understand the mechanisms that drive the distribution, abundance, and age structure of forage species in Prince William Sound.

Using acoustic telemetry to monitor Pacific herring during spring spawning

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As part of a pilot study designed to better understand pre- and post-spawn movements and dispersal of Pacific herring, *Clupea pallasii*, were surgically implanted with coded acoustic transmitters and passively monitored. Herring (194-255 mm SL; n = 25) were released into Port Gravina ~600 m north of the previously established Pacific Ocean Shelf Tracking (POST) project acoustic array. Twenty-three of the tagged individuals were detected multiple times (≤ 227 detections) on one or more days (≤ 5 d) post release. Two fish exhibited signs of post-tagging mortality and were excluded from analysis. All detections occurred at only one of the array's 13 receivers (60.68883°, -145.39903°), located approximately 600 m from shore and in 12 m of water. Peaks in detection frequency occurred throughout crepuscular and nighttime periods, with a significant decrease in fish detection during daylight hours. Concurrent detections of multiple individuals indicative of schooling behavior (≥ 2 fish detected/3 min interval) were observed in up to 43% of all detections and were primarily associated with high tide. Final detections of tagged fish coincided with the cessation of spawning in this area (14 April 2012), suggesting that fish may have departed Port Gravina into central Prince William Sound. This study was the first attempt to acoustically tag and release wild Pacific herring. Individual response to the handling and tagging procedures suggest that additional acoustic tagging studies on herring in Prince William Sound are feasible and may allow for further, more detailed examination of movement patterns. The ability to track and acoustically monitor herring is critical to our ability to better understand their stock structure, migration habits and the occurrence of skip-spawning, all of which may help to determine why herring populations are not recovering following the Exxon Valdez Oil Spill.

Hydroacoustic assessment of juvenile herring distribution in Prince William Sound

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Hydroacoustic surveys have been successfully conducted on adult Pacific herring (*Clupea pallasii*) in Prince William Sound (PWS), Alaska, for nearly two decades. In 2006, attempts were initiated to apply similar techniques to juvenile herring assessment. The objective was to improve understanding of the factors that governed herring recruitment. Earlier research during the Sound Ecosystem Assessment (SEA) program had generally described juvenile herring distribution and had suggested that mortality over the first winter was critical. The relatively large size of PWS necessitated the application of acoustic surveys, so our initial objective was to determine the distributional characteristics of age-0 herring that could be used to identify the presence of these fish. Our study design focused on pre- and post-winter sampling to investigate over-winter mortality and complemented concurrent studies on the energetic characteristics and disease potential in juvenile herring. From 2007 to 2012, we surveyed multiple bays in Prince William Sound including the bays covered by the SEA program: Whale Bay, Eaglek Bay, Simpson Bay, and Zaikof Bay. While the biomass index (kg/m^3) of juvenile herring varied greatly by bay, year, and season their abundances were higher near the heads of bays and in the upper 25 meters of the water column. The major challenges to improved quantification are the species identification and uncertainties in the degree of over-winter movements among locations. These aspects are the focus of future research.

Development of polymorphic EST markers in three commercially important *Sebastes* rockfishes in the North Pacific

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Discerning population structure of marine fishes with potential for extensive pelagic larval dispersal has been a longstanding challenge for fisheries management. EST-SSRs are microsatellites (aka simple sequence repeats) found within transcribed genes. Therefore, their polymorphisms are more likely affected by divergent natural selection that produces local adaptation and enhanced levels of genetic differentiation within partially-isolated fish stocks. We developed and tested 46 EST-SSR markers within three important rockfishes in the Gulf of Alaska, *Sebastes alutus*, *S. polyspinis*, and the *S. aleutianus* species-complex. We developed PCR primer pairs from 13 novel EST-SSR loci obtained from public *Sebastes* EST databases and redesigned primer pairs from six published EST-SSR loci. Amplification and diversity data from these and 27 previously published EST-SSR loci are reported for *S. polyspinis*, *S. alutus*, and two cryptic sub-types of *S. aleutianus*. Loci were moderately polymorphic, with heterozygosities averaging 0.44, and allele number averaging 5.2 across all loci and species. Divergence between the two *S. aleutianus* sub-types was high (mean FST = 0.33) allowing for unambiguous identification. Moreover, half of the six most divergent loci mapped to a single chromosome in the stickleback *Gasterosteus aculeatus*. Attempts to map loci and combine signals across putatively linked loci may allow higher resolution of genetic signals that result from the sections of a species' genome that are responsible for local adaptation.

Gulf of Alaska - Fish and Fish Habitat

A test of sampling methods designed to improve estimation of at-sea discards: NPRB Project 1017 Alternative catch monitoring of Alaskan groundfish

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The North Pacific Observer Program oversees the deployment of independent observers into the commercial groundfish fisheries of Alaska. Both retained and discarded portions of the catch are deducted from quotas in-season using catch estimates based, in large part, on observer data. On trawl catcher vessels, catches are difficult to sample. Observers work on the trawl deck where sampling space and access to catch is limited. Due to these sampling challenges, the haul-specific catch estimates may have high variance. Many factors contribute to the variance in estimates of species-specific catches and at-sea discards, including difficulty in 1) sampling and resulting small sample fractions 2) estimating the size (weight) of the total catches, and 3) determining the percentage of each species that is discarded at sea. We conducted a cooperative study on commercial fishing vessels to test an alternative methodology designed to decrease variance in catch and discards estimates. The alternative methods sample the portion of the catch that would be discarded directly while the standard methods sample from the entire catch. By focusing sampling on the at-sea discards and relying on shoreside reports of retained catch, the sampling efficiency of observers and precision of catch estimates may be improved. Two observers were deployed into three fisheries (on 12 trips) and simultaneously sampled catches using the two sampling methodologies. The alternative methodology was successfully implemented in two of the three fisheries; however, logistical constraints decreased sampling effectiveness in the third. Observers were unable to collect multiple samples under both methodologies, preventing variance estimation, although this occurred more often for the observer using standard methods. Although catch estimates from the two methods were not found to be significantly different, catch estimates under the alternative methodology had smaller variances than standard methodology estimates for 64% of hauls where variances could be computed. The limitations of both methodologies will be compared along with sampling results and catch estimates. The implications of the results to fisheries management will be discussed.

Early Marine Growth Patterns of Situk River Steelhead, *Oncorhynchus mykiss*

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Steelhead trout, *Oncorhynchus mykiss*, are a highly valued sport fish that has suffered severe declines across the southern portion of their range. Alaskan populations are generally considered stable, but a lack of stock specific data and the small size of many populations render them susceptible to overharvest and natural environmental variability. A retrospective analysis of steelhead scale samples from the Situk River will investigate possible correlations between juvenile critical period growth and potentially influential marine and freshwater environmental conditions. A preliminary Situk steelhead abundance model describes the significance of harvest, local sea-surface temperature, and El Nino Southern Oscillation (adj. r^2=0.62, P<0.01, n=23) in describing past variability for this population. This analysis will seek to understand how variability in Gulf of Alaska productivity due to climate forcing may potentially impact vulnerable Alaskan steelhead, and may also inform recovery of depleted stocks in Oregon, Washington, and California.

Fish down regulating their metabolism – A clue in over-winter survival, evidence and implications with Pacific herring (*Clupea pallasii*)

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For animals, reducing basal metabolic rates (BMR) is a way to overcome periods of low food availability. Most people think of bears hibernating when considering this survival strategy, but this strategy is not limited to bears. Zooplanktivorous fish at high latitudes also respond to food scarcity by decreasing their metabolic rates. While evaluating over-wintering strategies of Prince William Sound Pacific herring, evidence was found of herring reducing BMR by up to 67% during low food periods. We observed a decrease in metabolic rate in fasting Pacific herring (*Clupea pallasii*) held in captivity. Down regulation was demonstrated by observing that the rates that fish burned their stored energy slowed down after experiencing low food periods. We compared the observed energy content of fasted herring with predictions from a bioenergetic model to estimate the extent to which herring reduced their metabolic rates. Bioenergetic models using normal BMR parameters indicated that weight predictions of starving age-0 and age-2 herring were underestimated by up to 60% and 49%, respectively. Thus, a downward adjustment of the model value for BMR by 67% led to predictions within 10% of the observed values. While reducing BMR may prolong the time to starvation there may be other important fitness costs associated with down-regulated BMR. Winter is a critical period in the early life history of fish at high latitudes and winter mortality rates can exceed 90%. Much of this mortality relates to reduced access to food. Our finding that Pacific herring respond to reduced foraging success by down-regulating metabolic rates illustrates an overlooked mechanism fish use to overcome periods of food scarcity.

Inshore acoustic surveys in the eastern and central Gulf of Alaska

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During 2011, a series of replicate (spring/summer/fall) acoustic surveys were conducted in 10 inshore bays in Southeast Alaska and the Kodiak Island/Kenai Peninsula area as part of the Gulf of Alaska Integrated Ecosystem Research Program. The surveys were conducted using a towed acoustic system on a 50' vessel in inshore areas, and a skiff with a pole-mounted transducer was used to access nearshore areas that were unnavigable with the larger vessel. The species composition of acoustically detected aggregations was identified by jigging, deployment of an underwater camera system, and a small midwater trawl. Water column characteristics (e.g., temperature, salinity) and zooplankton concentrations were also measured throughout each bay. These surveys will be repeated in 2013. The goals of this ongoing work are to determine seasonal patterns of fish distribution at inshore locations and relate those patterns to habitat features. Spatial comparisons (within and between regions) and temporal comparisons (season and year) are a central focus of these investigations. In this poster, we present preliminary results from the 2011 surveys.

Young of the year rockfish in the Gulf of Alaska

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Young of the year (YOY) rockfish in the Gulf of Alaska (GOA) occupy the offshore epipelagic zone during their first few months of life before settling to the benthos. This portion of the water column's physical characteristics is influenced by the state of the El Nino-Southern Oscillation (ENSO) cycle that shifted from positive to negative from 2010 to 2011. During these two years the GOA also experienced variability in sea level pressure, sea surface temperature, and surface water nutrient concentration which may influence health and survival of larval fish in the surface waters through the availability of plankton prey, predators, and metabolic costs. YOY rockfish collected during the summer of 2010 and 2011 in Southeast GOA as part of the GOAIERP fisheries oceanography survey were processed for diet composition, calorimetry, lipid level, and protein content. YOY rockfish species are difficult to distinguish using morphometric characteristics, so a genetic analysis that used Single Nucleotide Polymorphisms (SNPs) was performed to validate species composition and confirm that the focal species Pacific ocean perch (POP) was targeted. YOY rockfish decreased in relative abundance from 2010 to 2011 in Southeast GOA, and this study focuses on the influence of variable ocean conditions on POP energetic content, proximate composition, and feeding habits during the epipelagic life stage.

Analysis of benthic communities on Alaskan weathervane scallop beds

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We report progress on a multivariate statistical analysis of benthic communities in areas targeted by Alaska's commercial weathervane scallop (*Patinopecten caurinus*) fishery and in nearby regions where no scallop fishing occurs. Weathervane scallops co-inhabit areas with commercially valuable fish species such as walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), yellowfin sole (*Limanda aspera*), and northern rock sole (*Lepidopsetta polyxystra*). Few observations are available on essential fish habitat (EFH) and the benthic communities that support the productivity of these commercially important species. These species are incidentally caught in the scallop fishery and sampled by onboard observers, who have routinely collected bycatch data from scallop fishing vessels since 1993. Using observer bycatch data from commercial scallop dredges from 1993-2011, as well as CamSled image data from video surveys conducted by the Alaska Department of Fish and Game, we will estimate: (1) spatial patterns in community composition on weathervane scallop beds in the Gulf of Alaska, Bering Sea and Aleutian Islands, and relationships to environmental factors (e.g., depth, substrate type, currents, water temperature), and (2) interannual changes in species composition that may be related to climate forcing (e.g., temperature variability) and anthropogenic effects (e.g., dredge and trawl fishing intensity). We will also utilize CamSled observations to measure the impacts of scallop dredging on benthic habitat, comparing areas open and closed to fishing off of Kodiak Island, AK. Results from this study will provide information to scientists and fishery managers on benthic community composition and associated habitat to improve EFH definitions for federally managed species of groundfish, scallops and crabs. Benthic community compositions on scallop beds may also serve as useful indices of climate change in Alaska.

Epidemiology of the parasite *Ichthyophonus* in Pacific halibut (*Hippoglossus stenolepis*)

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The internal parasite, *Ichthyophonus*, was detected in Pacific halibut (*Hippoglossus stenolepis*) throughout the eastern North Pacific. Prevalence of infection measured at ten longline survey sites ranged from 15% near Attu Island to over 70% in Prince William Sound, with a mean overall prevalence (Bering Sea to Oregon Coast) of 47%. Prevalence in smaller halibut (<50 cm) captured by trawl in the Bering Sea and Aleutian Island was 2.4% indicating infections establish after some ontogenetic shift in diet, habitat, or behavior. The prevalence of infection reported here is higher than that which occurs in sympatric fish species including other pleuronectids, suggesting that either susceptibility and/or infection pressures are higher in Pacific halibut. While ichthyophoniasis has been shown to reduce growth rate, decrease swimming stamina, and cause mortality in other fish hosts, its effects on Pacific halibut are unknown.

Mesoscale spatial distribution of pelagic forage fishes over a highly productive submarine bank in the Gulf of Alaska: Is there an optimal stability 'window'?

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Forage fish distribution patterns at mesoscales (0.1's to 10's km) affect feeding behavior and efficiency of many pinniped and seabird species. Identifying physical factors contributing to forage fish distribution patterns helps to understand and possibly forecast how climate events and oceanographic features contribute to the trophodynamics between forage fishes and their predators. In this study, data collected from acoustic-trawl surveys over Portlock Bank, a highly productive submarine bank in the Gulf of Alaska, in May and August of 2003 and 2004 were used to 1) describe mesoscale distribution of capelin (*Mallotus villosus*) and age-0 walleye pollock (*Theragra chalcogramma*), two important local forage fish species, and to 2) explore the relationship between the distribution patterns of the two forage fish species and the spatial pattern of water-column stability over the Bank. For the second objective, area biomass density (kg/km^2) was examined in relation to spatially interpolated stratification parameter (ϕ). When only considering biomass density values of the highest order of magnitude (≥ 10% of the maximum value) in each survey, a consistent pattern was found among surveys: areas with the highest biomass density were more likely to be associated with intermediate levels of ϕ. In comparison, there was no consistent pattern when considering all positive biomass density values. It appears that an optimal water-column stability 'window' was present for the dense aggregations of both capelin and age-0 pollock over the Bank.

Three Amigos – An intertidal monitoring program for coastal communities

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The Three Amigos project outlines an approach for environmental monitoring of intertidal biota by coastal community groups. By implementing a simple, photo-based monitoring program, environmental conditions can be recorded, and such documentation can provide a good baseline of natural climatic cycles (such as el Niño events) as well as anthropogenic-generated change (e.g., oil spill impacts). Photos at fixed locations provide the primary observational record. Photo locations are systematically selected based on existing habitat data that include wave exposure, substrate, accessibility, and in some cases, cultural relevance. Photos are collected at a variety of intervals (daily [via time-lapse cameras], quarterly and annually) to capture both short and long-term change. For this project, three prominent intertidal organisms are used for monitoring: barnacles, mussels and rockweed (the Three Amigos); these species co-occur within the upper intertidal zone but often show large, year-to-year variation in coverage. The effort to collect, manage and categorize this dataset is estimated to require days to weeks per year with minimal previous expertise, so the approach is highly amenable to implementation by community groups. Examples from Kachemak Bay are used to illustrate the proposed sampling methodology.

Influence of temperature on viral hemorrhagic septicemia in Pacific herring

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An inverse relationship between water temperature and susceptibility of Pacific herring (*Clupea pallasii*) to viral hemorrhagic septicemia (VHS) was indicated by controlled exposure studies where cumulative mortalities, viral shedding rates, and viral persistence in survivors were greatest at the coolest exposure temperatures. Among groups of specific pathogen-free (SPF) Pacific herring maintained at 8, 11, and 15°C, cumulative mortalities after waterborne exposure to viral hemorrhagic septicemia virus (VHSV) were 78%, 40%, and 13%, respectively. The prevalence of survivors with VHSV-positive tissues 25 d post-exposure was 64%, 16%, and 0% (at 8, 11 and 15°C, respectively) with viral prevalence typically higher in brain tissues than in kidney / spleen pools at each temperature. Similarly, geometric mean viral titers in brain tissues and kidney / spleen pools decreased with temperature, and kidney / spleen titers were generally 10-fold lower than those in brain tissues at each temperature. This inverse relationship between temperature and VHS severity was likely mediated by an enhanced immune response at the warmer temperatures, where a robust type I interferon response was indicated by rapid and significant upregulation of the herring Mx gene. These results indicate that low water temperatures should be included in a list of risk factors that predispose Pacific herring populations to VHS epizootics, including the presence of persistent VHSV carriers in a population, low levels of herd immunity, diet, concentration of shed virus in embayments or fjords containing limited water exchange, and amplification of waterborne virus from infected individuals.

Preliminary results on the age validation of big (*Beringraja binoculata*) and longnose (*Raja rhina*) skates using bomb-derived radiocarbon

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Directed fisheries for big skate (*Beringraja binoculata* [formerly *Raja binoculata*]) and longnose skate (*Raja rhina*) have re-emerged in the Gulf of Alaska. However, due to their life history traits (i.e., low fecundity, long life span, slow growth, and late age at maturity) these species may be at risk of severe population declines and overexploitation. Assessment advice for these species will require accurate age estimates in order to provide robust descriptions of age at maturity, growth and mortality rates. The current methodology for age estimation for these species relies on thin sectioning of vertebrae for growth band counts. Age and growth curve estimates have been produced for big skate and longnose skate populations in the Gulf of Alaska, British Columbia and California. However these studies have not produced similar results for either species, highlighting the need for age validation. Archived large specimens of big skate and longnose skate collected in 1980 and 1981 had minimum age estimates old enough to suggest that radiocarbon (^{14}C) signals from bomb testing conducted in the late 1960s can be used to establish dates of growth band formation. We present preliminary results of the $\Delta^{14}C$ in these samples and compare them to reference $\Delta^{14}C$ marine teleost otolith chronologies that exist for the North Pacific. Validation of this and improved age determination methods will lead to the development of suitable criteria for growth band counts and inter-agency standardization in age estimates throughout the range of both species.

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

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An overwinter mortality model based on whole-body energy density observations and forced fasting experiments was applied to age-0 Pacific herring (*Clupea pallasii*) of Prince William Sound, Alaska. The frequency distribution of energy density measured during November (2007-2011) was used as model initial conditions. The model was validated by comparing observed energy distributions in March (2008-2011) to model predictions. The model predicted ~90% mortality between November and March. Additional evidence is needed to validate the hypothesis that mortality from starvation drives recruitment variation in Prince William Sound. Observations of November and March energy density of cohorts recruiting at ~1 billion age-3 herring are needed to resolve whether low energy conditions at the beginning of winter or starvation during winter drives 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 (parasitic copepods) on age-0 herring during their first months following metamorphosis suggest this as a possible energy sink.

Gulf of Alaska - Fish and Fish Habitat

Spatial variation in abundance and condition of juvenile chum salmon (*Oncorhynchus keta*) in response to marine factors in Southeast Alaska

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Chum salmon (*Oncorhynchus keta*) are an important resource in Southeast Alaska, but little is known about the mechanisms affecting the critical early life stages in nearshore and coastal marine environments and how these mechanisms influence survival. Our objectives are to 1) determine inter-annual, regional and stock–specific differences in abundance and condition of juvenile chum salmon and 2) explore the relationship between environmental variables and juvenile chum salmon abundance and condition in northern Southeast Alaska. Two projects, the Gulf of Alaska Integrated Ecosystem Research Project (GOAIERP) and the Southeast Alaska Coastal Monitoring Project (SECM), collected juvenile chum salmon and biophysical data in 2010 and 2011 from offshore and inshore stations in Southeast Alaska, respectively. Stations sampled correspond to a major migratory pathway juvenile chum salmon utilize each summer from the northern region of Southeast Alaska out to the Gulf of Alaska. We used linear mixed-effects models to analyze the condition of juvenile chum salmon across station, stock-of-origin and region for both sampling years. Regression models with environmental covariates examined the relationship between environmental variables and juvenile chum salmon condition. Findings from this study may provide a better understanding of the relationship between environmental variation and the early marine residency of juvenile chum salmon in Southeast Alaska.

Larvamap - Larval transport and larval behavior for the North Pacific

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Larvamap is an open-access larval transport modeling tool. The idea behind Larvamap is to make it easy for researchers everywhere to use larval transport models to explore and test hypotheses about the early life of marine organisms. It has been designed with a web-based interface, runs on the Amazon cloud and will be available to the public by late 2012. The three main parts of Larvamap are the ocean circulation model, the particle tracking model and the larval behavior toolbox. Larvamap was initially tested with NASA/JPL Prince William Sound circulation model, but can use any other circulation model available via the OPeNDAP/THREDDs protocol. The behavior toolbox allows researchers to design a suite of behaviors (e.g., diel vertical migrations) specific to the organism, and interfaces with the particle tracking model to predict where larvae will go based on their behavior and the currents in the area. Behaviors can change at stages of larval life according to developmental milestones. Options are available to include temperature related growth rates of larvae, salinity gradient detection and settlement preferences. Model outputs include visualization of 3-d particle tracking, central trackline of trajectory, gridded probability maps, average depth and speed of particles at any given time step. Model output can be exported in standard ArcGIS format. We have tested Larvamap by running models of transport of Dungeness crab and Pacific herring larvae in Prince William Sound.

Offshore density distributions of fish and macrozooplankton in southeast and central Gulf of Alaska

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The Gulf of Alaska (GOA) is a highly productive marine ecosystem, supporting fisheries and populations of seabirds and marine mammals. The complexity of the GOA's topography, circulation patterns, and climatic forcing produces high variability in the physical environment across a wide range of spatial and temporal scales. It is poorly understood how variability in the physical environment influences the species composition, relative abundance, and distribution patterns of marine organisms in the GOA's offshore environment. To identify how different species are influenced by environmental variability in the GOA, it is necessary to quantify variability in organism distribution patterns. An active acoustic survey was conducted in southeast and central GOA during summer and fall (July – October) 2011 as part of a survey for plankton, fish, seabirds, and marine mammals. Density distributions of fish and macrozooplankton were quantified throughout the water column along systematic transects in both regions using a 38 kHz splitbeam echosounder during daylight hours. Acoustic targets were verified by surface and midwater trawling. Acoustic backscatter (area backscatter coefficient, sa) measured from 15-250 m was classified as piscivorous fish, forage fish, macrozooplankton, or mesopelagics. Backscatter measured between 250-500 m was used as an index of density. Distributions of backscatter categories were mapped for each region and season to illustrate spatial and seasonal changes in density. Preliminary analysis indicates that density distribution is correlated with a combination of topographic features and strong oceanographic mixing (e.g., shelf breaks and edges of submarine gullies/banks). Seasonal differences in horizontal and vertical density distributions were also evident in both regions. The diversity of acoustic targets and species compositions encountered in trawl catches makes species-level classification of acoustic backscatter a challenge.

Pilot-scale development of laser ablation – Isotope ratio mass spectrometry (LA-IRMS) for use in retrospective studies of marine productivity in the North Pacific Ocean

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Stable isotope analysis (SIA) is an important tool for characterizing energy flow and trophic relationships in aquatic ecosystems and typically involves contemporary analysis of whole organisms and tissues, or of archival samples that are collected and maintained because of their scientific or economic significance. Archives of otoliths, scales and bone of commercially important fish species can be of particular value in SIA because they provide an opportunity to retrospectively identify factors that influence long-term changes in stock abundance, but their analysis has been generally restricted to whole or partial sample measurements that represent an integrated lifetime or temporally limited isotope signal. Laser ablation – isotope ratio mass spectrometry (LA-IRMS) is a recently developed technique for SIA that uses spatially resolved isotope analysis to overcome these limitations and provide estimates of annual and even seasonal energy flow from archived samples with resolution that was previously unavailable. We are testing the utility of this technique to determine the relationship between carbon isotope values within herring scales and whole herring from Prince William Sound by comparing samples of these fish obtained during energy rich (fall) and energy depleted (spring) time periods. Establishing this relationship will determine if the extensive (Alaska Dept. of Fish and Game) scale archive for this population can be used in a subsequent retrospective analysis to provide information aimed at understanding the dynamics of fish stocks during a period of major biological and physical change in the North Pacific Ocean (ca. 1970 to present).

Benefits of living life on the edge: Enhanced growth and foraging opportunities for juvenile salmon inhabiting the margins of the Sitka eddy

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Salmon stocks from Alaska, British Columbia, and the Pacific Northwest use the Gulf of Alaska as a migratory corridor which could lead to inter- and intraspecific competition during years of high density or spatial overlap. Juvenile pink (*Oncorhynchus gorbuscha*), chum (*O. keta*), and sockeye (*O. nerka*) salmon from these regions inhabited coastal Gulf of Alaska (GOA) during July 2010 and were distributed throughout the Sitka eddy; this study seeks to conduct a basic investigation into how these often large, prominent, and dynamic oceanographic features may influence the health and ultimately the survival of salmon during early ocean residence. Measures of salmon growth rate, energetic condition, and prey quality were contrasted with geographic position of fish within the eddy as measured by sea surface height. Fish located along the eddy perimeter displayed the highest levels of insulin-like growth factor, a hormone that is indicative of elevated short term growth rate. Plankton density was also greatest around the eddy perimeter. Depending on the position and strength of the Sitka eddy and outmigration timing, the resulting positive effects on habitat and foraging opportunities in the GOA may mitigate effects of competition and result in increased survival for certain salmon stocks.

Gulf of Alaska - Fish and Fish Habitat

The distribution and diet of larval arrowtooth flounder, *Atheresthes stomias*, in the Gulf of Alaska

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Arrowtooth flounder became prominent in the Gulf of Alaska ecosystem following an ocean climate regime shift in the late 1970s. Currently, arrowtooth flounder are the most abundant groundfish species in the Gulf of Alaska. Although arrowtooth flounder are not economically important, they are a voracious predatory species that competes and preys upon economically important species within the Gulf of Alaska. Understanding the factors influencing successful recruitment of this ecologically important species has become imperative. How oceanographic conditions impact the distribution and diets of larval arrowtooth flounder may shed some light on how successful recruitment is annually.

Do respirometry studies adequately parameterize bioenergetic models?

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Bioenergetic models are frequently used to evaluate the impacts of climate change on fish populations. However, the laboratory conditions under which key parameter values are measured can introduce significant error into the models. We cultured wild-caught Pacific herring for different amounts of time and evaluated their oxygen consumption rates at various swimming speeds. After controlling for temperature and fish size we observed a direct relationship between the amount of time since capture and oxygen consumption rates at fixed swimming speeds. These data indicate that the conditions under which parameter values are obtained should be considered when applying bioenegetic models to wild applications.

Growth and changes in body composition over winter in juvenile Pacific herring (*Clupea pallasii*) from Prince William Sound

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Winter survival rates can vary widely for young-of-the-year (YOY) fish and strongly influence year-class strength. Their survival often depends on having sufficient energy stores to endure food scarcity in winter until zooplankton abundance increases in spring. We are assessing the 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 rate predicts winter survival, with faster growing fish better able to store lipid energy reserves. In our three-year study, we found that overwinter changes in growth rate, size, and body composition of YOY herring differed among bays in PWS, and across years. Overwinter conditions therefore vary greatly among bays and between years, in some cases leading to size-dependent mortality, and growth in others. If the overwinter survival of YOY affects recruitment then these data demonstrate that overwintering habitats do not uniformly contribute to recruitment and the quality of specific overwintering habitats varies annually. This suggests maintenance of a variety of wintering habitats may be a key element in ensuring herring recruitment. When pooled across bays and years, growth rates in fall did not show the expected positive relationship to fall energy stores, but were inversely related to length. Small YOY herring appear to allocate energy in fall to maintain high growth rates at the expense of building energy reserves. Winter survival of YOY herring may depend on achieving large size through high growth rates prior to our late fall sampling period, or sufficient zooplankton availability through winter months that smaller individuals may supplement energy reserves through foraging.

Nucleic acid ratios as a growth and condition index in larval fish, using Pacific herring (*Clupea pallasii*) as a study species

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Growth of larval fish determines future growth and survival, and thereby influences recruitment. Typically, larval abundance is used to predict recruitment, but larval condition may be a better index of long-term survival. However, unlike larval abundance, studying larval growth and condition can be difficult due to their low tissue mass and fragility. Understanding larval condition requires sensitive growth indices that are relatively quick and inexpensive. Cellular nucleic acid ratios (RNA/DNA) rapidly shift with changes in nutritional states and can be used as a growth index in fish. Nucleic acid ratios can be calibrated with measured larval growth rates in the laboratory, enabling use of this index to estimate growth/condition in field-caught samples. Here, we show that the nucleic acid (RNA/DNA) ratios of individual cultured Pacific herring larvae (0-56 days post hatch) clearly distinguish larvae in the fed and starved states. The preliminary data indicate a threshold RNA/DNA ratio (~1.45) in starved larvae, below which they could be considered at terminal starvation. Examining RNA/DNA ratios in conjunction with yolk depletion suggests that larval herring can withstand up to 3 days of starvation after yolk depletion. Nucleic acid ratios can be a valuable metric of nutritional condition in larval fish, and therefore may be useful for identifying habitats that disproportionately support fish production.

Gulf of Alaska - Fish and Fish Habitat

Bayesian hierarchical analysis of environmental influences on Alaska marine fish and crab recruitment

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Knowledge of environmental influences on the productivity dynamics of marine fishes and crabs will allow for improved assessment and management of these stocks. Utilizing information about shared susceptibility to environmental influences during critical early life stages across stocks may allow us to better identify environmental influences important to recruitment. For the Gulf of Alaska and Eastern Bering Sea/Aleutian Islands ecosystems, we generated hypotheses regarding shared sensitivity to key drivers of recruitment – transport, food availability, and predation – and used those to group stocks that might share similar recruitment dynamics. For example, for the Gulf of Alaska we hypothesized inshore transport and retention of larvae to be important to successful recruitment, especially for slope-spawning species. We grouped stocks based on spawning and juvenile locations and used indices of freshwater runoff, coastal upwelling, and the Aleutian Low as environmental covariates. Using a Bayesian hierarchical modeling framework, for each hypothesis we modeled recruitment estimates from stock assessments as a linear function of environmental covariates with the coefficients estimated from a group level distribution. The model fitting for each stock was informed by the other stocks within the group, reducing the occurrence of spurious correlations. Preliminary results indicate the importance of several processes in explaining recruitment in these ecosystems. Results from this analysis can help in understanding environmental influences on recruitment for the stocks included in this analysis, and also data-limited stocks not included in this analysis based on similarities in recruitment dynamics or early life history traits.

Gulf of Alaska - Fish and Fish Habitat

Modeling the "gauntlet" from spawning grounds to juvenile nurseries: Individual-based models for the early life stages of 5 focal fish species in the Gulf of Alaska

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The Gulf of Alaska (GOA) supports important fisheries and the communities that depend on them. Understanding recruitment is central to rational fishery and ecosystem planning. Recruitment is likely to be controlled by physical (e.g., climate, transport) and biological processes (e.g., growth, predation) acting on the early life stages of marine fishes. As part of the Modeling Component of NPRB's Gulf of Alaska Integrated Ecosystem Research Program (GOA-IERP), we hypothesize that fish recruitment is mainly determined by processes acting on early life stages between offshore spawning sites and the end of the young of year (YOY) stage, the so-called "gauntlet". We are using the Regional Ocean Modeling System (ROMS), a Nutrient-Phytoplankton-Zooplankton (GOA-NPZ) model, and five Individual-Based Models (IBMs) to examine recruitment mechanisms and derive indices related to recruitment for five focal fish species: arrowtooth flounder, Pacific cod, Pacific ocean perch, sablefish, and walleye pollock.

Here we present conceptual frameworks for the five IBMs in a 2D (depth x cross-shelf location) format which identifies important biological information (e.g., life stage transitions, seasonality, development rates) incorporated in each model. The models serve as tools to integrate other components of the GOA-IERP that are oriented more toward field studies: the Upper Trophic Level, the Middle Trophic Level, and the Lower Trophic Level projects. In turn, these field studies, combined with retrospective analyses of existing data for the five focal species, are being used to initialize, validate and improve the models.

Based on preliminary results from the models, two associated posters present: 1) dispersal pathways between spawning/parturition and juvenile nursery grounds for each focal species and 2) a characterization of connectivity between spawning/parturition and juvenile nursery grounds for each focal species.

Gulf of Alaska - Fish and Fish Habitat

Modeling the "gauntlet" from spawning grounds to juvenile nurseries: Preliminary estimates of connectivity between spawning and nursery grounds for 5 focal fish species in the Gulf of Alaska

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Gulf of Alaska - Fish and Fish Habitat

Modeling the "gauntlet" from spawning grounds to juvenile nurseries: Preliminary estimates of dispersal pathways for the early life stages of 5 focal fish species in the Gulf of Alaska

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The Gulf of Alaska (GOA) supports important fisheries and the communities that depend on them. Understanding recruitment is central to rational fishery and ecosystem planning. Recruitment is likely to be controlled by physical (e.g., climate, transport) and biological processes (e.g., growth, predation) acting on the early life stages of marine fishes. As part of the Modeling Component of NPRB's Gulf of Alaska Integrated Ecosystem Research Program (GOA-IERP), we hypothesize that fish recruitment is mainly determined by processes acting on early life stages between offshore spawning sites and the end of the young of year (YOY) stage, the so-called "gauntlet". We are using the Regional Ocean Modeling System (ROMS), a Nutrient-Phytoplankton-Zooplankton (GOA-NPZ) model, and five Individual-Based Models (IBMs) to examine recruitment mechanisms and derive indices related to recruitment for five focal fish species: arrowtooth flounder, Pacific cod, Pacific ocean perch, sablefish, and walleye pollock.

Here, we present preliminary results from the models for dispersal pathways of each focal fish species during one simulated year (2001). We used ROMS to provide a temporally-varying, high spatial resolution environment (3D currents, temperature, salinity) within which we released thousands of simulated individuals from potential spawning/parturition sites across the GOA continental shelf and slope for the five focal fish species. Individuals progressed through a species-dependent series of early life stages (eggs, larvae, and juvenile), with varying degrees of active behavior and environmental influence. YOY-stage individuals that reached characteristic nursery habitats were regarded as "successful" in running the "gauntlet" and contributing to recruitment. Results generally indicate high losses due to advective transport, with mesoscale eddies (depending on specific circumstances) enhancing either local retention near the shelf edge, onshelf transport toward nursery areas or offshore transport away from nursery areas. Environmental conditions along trajectories of both "successful" and "unsuccessful" individuals varied substantially, indicating that local conditions along trajectories may also have substantial effects on recruitment "success".

Two associated posters present: 1) details of the species-specific IBMs and 2) a preliminary characterization of connectivity between spawning/parturition and juvenile nursery grounds for each focal species, based on the results shown here.

Age-dependent winter energetics of juvenile Pacific herring in the Gulf of Alaska

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Our general bioenergetic model for juvenile Pacific herring in the Gulf of Alaska indicates that their energetic strategy varies by age following the critical size hypothesis. Age-0 herring incur high energetic demands to grow rapidly to reduce their susceptibility to predators. Growth costs, small size, and relatively high metabolic rates preclude them from amassing energy stores for winter survival and therefore they must expose themselves to predation risk in order to forage. By age-1, herring are large enough to store appreciable energy over summer and can sustain themselves in part with endogenous energy in the winter while finding some sanctuary from predators. Upon reaching the size of large age-1's and small age-2's, they find relief from piscivorous predation and can forage more freely to maintain their overwinter energy content. Once herring have attained the size of large age-2's, they begin to incur reproductive costs in preparation for spring spawning. These data corroborate other findings that age-0's are the most susceptible to mortality because their small size forces them to forage, exposing them to predation. Cessation of feeding means certain death for age-0's, suggesting that unless food availability is limiting, predation pressure could be a greater source of mortality and thus be the mechanism regulating herring recruitment.

Variations in walleye pollock (*Theragra chalcogramma*) maturation rates in the Gulf of Alaska

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The life history and reproductive biology of walleye pollock (*Theragra chalcogramma*) are germane to the implementation of modern stock assessments for establishing the spawning stock biomass. Stock assessments often assume that spawning season is constant among years; however environmental conditions and population abundance influence the timing of maturation. Adult abundance and stage of reproductive maturity have been monitored in early spring in Shelikof Strait, western Gulf of Alaska, for almost three decades. Utilizing these data we developed generalized linear models to examine the oceanographic and population drivers of interannual trends in walleye pollock maturity.

Mapping Tanner crab habitat in the Kodiak area of the Gulf of Alaska

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Alaska Department of Fish and Game (ADF&G) manages commercial fisheries for Tanner crabs *Chionoecetes bairdi* in the Gulf of Alaska (GOA) and conducts annual bottom trawl surveys to assess the populations and provide data to set harvest limits. Bottom trawling is limited to trawlable habitat that comprises only a proportion of the total survey area. The current practice of expanding Tanner crab densities from trawlable habitat to large areas of unknown habitat can potentially create bias in overall population estimates; this is critical because state regulations require that population estimates exceed a lower threshold before opening Tanner crab fisheries. For a benthic species like Tanner crab, understanding the relationships between habitat and abundance is essential for extrapolating population density estimates to larger scales. The goal of this project is to map and describe important Tanner crab habitat northeast of Kodiak Island in the GOA. For the first time, we used WASSP multibeam sonar and a towed benthic imaging system (CamSled) to deliver full-coverage maps of bathymetry and seafloor acoustic backscatter and to provide both classified substrates and biological observations for Tanner crab habitat. Tanner crabs have preferred habitats and are associated with specific bottom characteristics that can be recognized in data collected by a multibeam sonar system: substrate, biota, and geomorphologic characteristics (depth, hardness, slope, rugosity). This information will be used to increase understanding of the spatial distribution of Tanner crab and their habitat and will aid in interpretation of stock assessment data.

Caspian terns breeding on the Copper River Delta: More to come?

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Along the Pacific coast, the Caspian tern breeding population has more than doubled since the 1980s. Coupled with this increase has been a recent rapid population expansion northward into Alaska. Caspian terns first appeared in Prince William Sound and on the Copper River Delta in 1983. Despite numerous attempts to locate Caspian tern nests, it was not until June 2005 that local fishers first discovered a breeding colony on Kokinhenik Bar, a barrier island at the mouth of the Copper River. Since 2008 we have documented the colony size and chronology, searched for birds previously banded at other colonies, and obtained diet information. At the colony, between 2008 and 2012 the number of nests increased from 188 to 338 nests. Caspian terns previously color-banded as breeders at colonies on the Columbia River and at San Francisco Bay have been observed on Kokinhenik Bar. We predict that in the near future, the Copper River colony will continue to grow as a result of intensive management practices being used to displace birds at Oregon's East Sand Island, the largest colony in North America. On a longer time scale, effects of climate change such as an increase in storm activity and flooding as well as a rise in sea level may negatively impact the suitability of Kokinhenik Bar as a colony site.

Long-term diets of black oystercactchers (*Haematopus bachmani*), evidence from stable isotopes - Preliminary results

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Black oystercatchers are conspicuous shorebirds of the North American Pacific coast and are considered an indicator species of the intertidal ecosystem by several government agencies. Despite their distinction, basic information about black oystercatcher diet is limited. This study uses a Bayesian analysis of stable isotopes of oystercatcher feathers and blood to identify the proportional contribution of major prey groups to black oystercatcher diet. Feather samples collected from several sites in the Gulf of Alaska are being compared to archival specimens obtained over a century of collection. The goals of this study are to determine tissue fractionation patterns in black oystercatchers, possible regional variability in diet in Alaska populations, and temporal variability over the last 100 years. Potential implications of this study include a greater understanding of the species' ability to shift its diet based on available prey.

Gulf of Alaska - Seabirds

New applications of radar, acoustic recordings and at-sea surveys for monitoring non-colonial seabirds (*Brachyramphus* murrelets) in Alaska

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The marbled murrelet (*Brachyramphus marmoratus*) and Kittlitz's murrelet (*B. brevirostris*) are cryptic, solitary-nesting seabirds that breed sympatrically in parts of Alaska. Population monitoring has been hindered by difficulties locating nests and by low power to detect trends in at-sea vessel surveys. Marine surveillance radar has been used routinely to census and monitor marbled murrelets elsewhere, but not in Alaska. Our goal was to develop a radar protocol suitable for monitoring murrelets under Alaskan conditions (two sympatric species, shorter nights, harsher weather, diverse nesting habitat, higher range of densities). We present spatial, seasonal and diurnal data collected during 109 radar surveys (18,300 murrelet detections) from 29 sites sampled in 3 years (2010-2012) in the Kodiak Archipelago and discuss the use of these data for refining radar protocols. We also present two unique applications of radar surveys. First, at varying spatial scales, we correlate watershed-level radar counts with vessel counts of murrelets in adjacent marine areas at 23 sites covering a range of terrestrial and marine habitats. High radar and at-sea counts (99% were marbled murrelets) were consistently associated with forested watersheds. Second, we compare radar counts with simultaneous automated acoustic recordings made during 13 dawn surveys. The highest call frequencies occurred in areas where circling flight behavior was observed by radar, generally over forests that provide high-quality nesting habitat for marbled murrelets. Overall, the integration of radar, at-sea and acoustic sampling can provide reliable methods to: a) identify population centers for both murrelet species; b) generate population estimates; and, c) conduct long-term monitoring of these populations in Alaska.

Pigeon guillemot (*Cepphus columba*) and pelagic comorant (*Phalacrocorax pelagicus*) on St. Lazaria Island as near-shore indicator species of the Gulf of Alaska ecosystem health

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Pigeon guillemots (*Cepphus columba*) and pelagic cormorants (*Phalacrocorax pelagicus*) are seabirds that nest on St. Lazaria Island, within the Alaska Maritime National Wildlife Refuge and located in the southeastern portion of the Gulf of Alaska. Both species are nearshore, central-place foragers during the summer breeding season which will allow us to study the occurrence of juvenile stages of commercially important fishes. Initial observations of guillemots have shown that juvenile rockfish (*Sebastes* spp.) are utilized by pigeon guillemots at St. Lazaria. By studying guillemot diets intensively (planned) and cormorant diets (collected historically and currently), we may better understand the population patterns we have seen and may yield a better understanding of prey availability and diversity. We propose to take advantage of the seabirds' life history strategies to monitor intra- and inter-annual prevalence of juvenile fishes. Guillemots forage within nearshore waters adjacent to the breeding colony and return to feed their young intact juvenile fish and macroinvertebrates; we plan to use digital photography to sample diet composition without interfering with feeding activities. Diets of cormorants, which can be inferred from undigested hard parts found in regurgitated boluses, have been collected at St. Lazaria throughout the past decade. Here we present population trends of both species of seabirds at St. Lazaria Island that have been studied since 1994 as well as the reproductive success of pelagic cormorants. Preliminary results of cormorant diet analysis will also be presented. This information may be helpful to commercial fisheries management and monitoring the health of the Gulf of Alaska.

Black-legged kittiwake productivity on the Kenai coast: A first look at a long-term remote video monitoring study

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We studied productivity of black-legged kittiwakes (*Rissa tridactyla*) near Cape Resurrection, Alaska, from 2010 through 2012 using a remote controlled video system. The purpose of this study was to test the feasibility of remote video cameras for monitoring productivity at our study site, and to provide baseline data of black-legged kittiwake productivity in the Kenai Fjords area. Nests were monitored from late May through August in El Dorado Narrows near Cape Resurrection. Within this sub-colony of about 2,000 nesting pairs, seventeen nest plots were randomly selected from the mainland and an adjacent island, and 30-second digital video clips recorded twice weekly for up to 143 nests within these plots. Number of nests, hatchlings (chicks per nest), and fledgling success (number of chicks fledged per nest) decreased from 2010 through 2012. In 2010, chicks were observed in 107 of 143 nests (74.8%), with 2 chicks in 15 of those nests, and fledgling success was high (62.2 ± 4.8% SE). In 2011, chicks were observed in 66 of 141 nests (46.8%), with 2 chicks in 3 nests, and a 34.0% (± 4.0%) fledgling success rate. In 2012, chicks were observed in 36 of 140 nests (25.7%), there was a single 2-chick nest, and fledgling success was 15.7% (± 3.1%). No nest in any year was observed to have produced more than 2 chicks. In 2012, there was a 17% decline in the number of nests during the month of July, which was significantly different ($H=11.24$, 2 d.f., $P= 0.004$) from a 7 and 8% decline recorded in 2010 and 2011, respectively. More nests were lost or destroyed at the island versus mainland nest plots by end of July 2012 ($H=16.245$, 1 d.f., $P< 0.001$). Additionally, within the island plots, only 35% of the original nests positioned lower on the cliffs were present versus 75% in upper sites ($H=24.194$, 2 d.f., $P< 0.001$). The reduced success of 2012 nests located lower on the island cliffs may be attributed to weather, with heavier July rains and big waves from several Gulf of Alaska storms, causing these more exposed nests to be washed away.

Gulf of Alaska - Seabirds

Fledgling feathers: Validating a new way to monitor nutritional stress in seabird chicks

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Seabirds are widely believed to act as indicator species of marine ecosystem health. Most species rely on lower trophic level prey species which makes them sensitive to changes in trophic web linkages that affect the availability of their food resources. Seabird responses to food shortages can be detected by measuring concentrations of the hormone corticosterone (CORT) in tissues of parents and their young. Identifying stress in seabird chicks can, therefore, provide information on the foraging conditions encountered by their parents. Methods to measure CORT, however, currently provide only short-term "snap-shots" of foraging conditions (hours to days) using blood plasma or fecal samples. We propose that CORT deposited in feathers can be an effective tool to gauge nestling nutritional stress over a longer temporal scale. We tested this method for two seabird species raised on experimentally controlled diets (Caspian terns *Hydroprogne caspia* and rhinoceros auklets *Cerorhinca monocerata*). We found that CORT deposited in feathers may or may not match the patterns observed in blood plasma depending on how chicks allocate limited food resources to growth. We conclude that measuring CORT in feathers is a valid technique but recommend that species-specific biological validation is conducted prior to sampling wild populations for monitoring purposes.

Pregnancy detection in diverse species of marine mammals: Increasing our options

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Logistically, marine mammals represent one of the most difficult species from which to obtain research samples. Even for those scientists interested in behavioral observations, costs for equipment, travel and staff are considerable. Research on the physiology of marine mammals is not only difficult but can be impossible when the species is large and must be investigated solely under free-ranging conditions. These logistical and financial constraints have led marine mammal physiologists to think “outside the box” when defining what constitutes a biological sample. This has also led to more critical analyses of how these unique samples are validated for use in descriptions of biological functions. Reproductive hormones have long been recognized as indices of the reproductive state of domestic mammals, fish and birds. These same hormones, progesterone, estrogen and testosterone, have been shown to have the same efficacy in describing the reproductive status of free-ranging terrestrial mammals and within recent years, we have been able to begin definition of the physiological patterns of reproduction in free-ranging marine mammals. While the hormones measured are the generally the same between domestic and marine species, the samples used and the modes of collection are not. For example, the use of progesterone in blue whale fecal samples to detect pregnancy resulted in a significant difference in progesterone concentrations between pregnant and non-pregnant animals (pregnant: mean 1387.77 ng/g feces; non-pregnant: mean 23.07 ng/g feces; P=0.003, n= 6 and 11, respectively). Further, progesterone measured in the blubber of pregnant and non-pregnant free-ranging harbor seals was shown to be significantly different between the two groups (pregnant: mean 134.35 ng/g blubber; non-pregnant: mean 1.66 ng/g blubber; P=0.016, n= 4 and 5, respectively). Fecal and blubber samples have the advantage of being a less invasive means of data collection, as well as producing pooled concentration values rather than the snapshot value provided by serum or plasma, and are not affected by transient stressors such as capture for sampling. Blubber and feces represent a means of increasing our sampling options while decreasing the amount of disturbance during collection.

Gulf of Alaska - Mammals

Studying the vocal repertoire of Cook Inlet beluga whales

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Cook Inlet beluga whales are a geographically and genetically isolated population. Between 1994 and 1998 their population declined by almost fifty percent. The decline was attributed to overharvest. The subsistence hunt ended voluntarily in 1999, but the population failed to recover. In 2008, Cook Inlet belugas were listed as endangered. Potential factors limiting the population's recovery have been proposed including underwater noise pollution. To address this issue, the vocal repertoire of Cook Inlet belugas was characterized. Bottom-moored hydrophones were deployed at Eagle River July 2009-August 2009 and Trading Bay July 2009-February 2010 sampling at 25000 Hz on a 10% duty cycle. Beluga calls were identified at Eagle River during summer 2009 and in Trading Bay during summer 2009 and winter 2009. Each call was quantitatively described, categorized as a whistle, pulsed call, or click train, and assigned a contour. The total number and relative abundance of each call type were calculated for each data set and compared to look for temporal or spatial variation. Then the calls were quantitatively analyzed in Matlab to determine call characteristics. The characteristics measured in Matlab were used to perform a principal component analysis. There was evidence of spatial and temporal variation in the relative abundance of call types and contour usage. 62.9% of the variation in the data was accounted for by the first principal component which was largely composed of the frequency characteristics of the call. Adding the second principal component, which was dominated by call duration and number of inflection points, explained 83.2% of the variation. Including the third principal component which was almost exclusively composed of the frequency range of the call, accounted for 93.8% of the variation in the data. Next, an anthropogenic noise study will be conducted to attempt to correlate differences in the ambient noise environment with differences in beluga calling behavior.

Acoustic monitoring of beluga whales in Eagle River, Cook Inlet

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Due to the endangered situation of Cook Inlet beluga whales (*Delphinapterus leucas*), there is a need to monitor their presence in the coastal portion of the Joint Base Elmendorf Richardson (U.S. Army and U.S. Air Force) in Knik Arm, upper Cook Inlet. In particular, a sensitive area is Eagle Bay in the periphery of a firing range and Eagle River, crossing that range. A pilot study was set up from May to November 2011 to continuously monitor (24/7) the acoustic presence of belugas at four different locations in Eagle River, covering the last 3652 meters of the river upstream from its mouth in Eagle Bay. A total of 168 days were successfully sampled and belugas were detected on 37 of those days by one or more echolocation logger (C-POD, Chelonia Ltd, U.K.). The lowest percentage of days sampled by each C-POD that had beluga acoustic detections was at the two upstream locations, and the highest at the two downstream locations (closer to the river mouth). Belugas were absent during May, June, and July and were first detected on August 5th. The highest number of encounters occurred in August, gradual decreasing through September, October and November. The time spent by belugas in the river varied from a few minutes up to several hours, 1 hour and 12 minutes being the 95th percentile. Based on the spatial distribution of encounters across the 4 locations and the time intervals of encounters, movements within the river were successfully tracked. From all the encounters detected, 34% traveled upstream to the first location (nearest to the river mouth), 57% traveled to the second, 15% to third and 6% to the fourth (3652 meters upstream from the river mouth). On average, belugas took between 8 to 28 minutes to travel between locations. The deployment of C-PODs in Eagle River to acoustically detect belugas and describe the use of a considerable section of this river was successful. This pilot study proved that acoustic techniques are promising for the continuous monitoring of belugas in Cook Inlet rivers.

30 years of data from stranded and hunter-harvested Cook Inlet beluga whales: Creation of a web-based database

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The endangered Cook Inlet (CI) beluga (*Delphinapterus leucas*) whale population has declined over the past 30 years from an estimated 1,293 whales in 1979, to an estimated 284 whales in 2011. Despite the cessation of subsistence hunting, assumed to be a major contributor to the decline in the 1990s, and intensive research efforts, the factor(s) driving this decline and lack of expected recovery remain unknown. The National Marine Fisheries Service (NMFS) has obtained Level A (basic stranding information) and ancillary data for more than 300 stranded and hunter-harvested Cook Inlet beluga whales over the past 30 years (called the 'stranding records'). This data serves as an incredible source of information about this population and includes, to varying degrees, information about sex, age, morphological measurements, spatial, and temporal distribution, as well as necropsy reports, stomach content analyses, contaminant burdens, reproductive status, and more. However, this dataset was largely inaccessible and cumbersome to utilize as it had been stored as hard-copies. For this project, all available CI beluga stranding records were synthesized, verified, missing reports located, then digitized, and entered into an Oracle XE database web application, with Google Maps functions, designed and developed with NMFS and Finsight, LLC. This query-able database will provide NMFS with a tool to access and analyze the CI beluga stranding/harvest data to better manage and direct research efforts for this declining population. Next steps include conducting a retrospective analysis of the Level A data to describe the strandings (i.e., summarize total number of whales, including sex, age, locations and timings of strandings) and to identify any potential correlations between the strandings and various parameters (e.g., do certain age/sex strandings occur more in one location/month/year than others). The results of the future retrospective analysis may be informative for future management recommendations and research priorities.

Predicting encounters between humpback whales and cruise ships in southeast Alaska

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Reducing the deleterious impacts of shipping on population of large whales is a global conservation and management issue. In southeastern Alaska, cruise ships constitute the most numerous type of large ship during the summer, and thus encounter many whales while in hotspots such as Frederick Sound, Sitka Sound, Icy Strait and Glacier Bay. Ship pilots and captains are interested as to whether encounters with whales are predictable in order to increase situational awareness while traversing an area. Our goal for this project is to understand whether the probability of a close encounter between a ship and a humpback whale has any predictive capacity at relatively small spatial and temporal scales relevant to ship captains and pilots. We used data collected over the past 7 years (2006-2012) from 422 cruise ship entries into Glacier Bay, and 1413 unique encounters between ships and whales recorded by observers placed aboard cruise ships to model the probability of a close encounter (<250 m from the bulbous bow). We used explanatory variables as tidal stage, sea surface state, ship speed, ship entry order into the park, and distance to shore. Although analysis is ongoing, preliminary results demonstrate that encounters are predictable in space and time. We will present our results based on probability of an encounter and presented in a manner that can be both easily summarized and communicated to ships prior to entering the park.

Population dynamics and behavior of Steller sea lions at Forrester Islands, Alaska

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Based on repeated sightings of marked individuals, we estimated annual variation in population parameters and behavioral measures for Steller sea lions at Forrester Islands (FI), Alaska, from 2000-2012, to assess correlations among these measures, and between these measures and environmental variables, to evaluate their utility as indicators of ecosystem change. Population parameters we used were adult survival, early pup mortality, reproductive rate and abundance; behavioral measures were timing of pupping, seasonal use by non-breeders and time ashore. We also assessed the utility of counts versus observations of marked individuals for capturing meaningful annual variation (i.e., related to environmental change). For annual adult survival, we found (1) significant annual variation, particularly for males, (2) senescence after age 12, particularly for males, and (3) higher survival and less annual variation for adults that used the productive areas in northern southeastern Alaska where high population growth and juvenile survival have been observed.

Do age ratios accurately reflect marine mammal population dynamics?

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Age ratios (i.e., calf/cow, pups/non-pups, juveniles/adults) are used to predict population trajectories, or to estimate vital rates such as natality or juvenile survival to inform management decisions for exploited or threatened terrestrial or marine mammals. However, the reliability of such indicators to accurately reflect the underlying dynamics of a population has not been evaluated for marine mammals. Matrix modeling shows that age ratios and birth rates differentially track population trajectories whenever effectors such as survival and predation do not equally change across all ages. This suggests that age ratios are likely to provide ambiguous inferences without additional demographic information, in particular on density, or trajectory dependence of effectors.

Age-specific reproductive characteristics of northern sea otters (*Enhydra lutris kenyoni*) in southeast Alaska

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Northern sea otters (*Enhydra lutris kenyoni*) were extirpated from southeast Alaska in the late 1800s due to extensive hunting by fur traders. They were reintroduced successfully to the area from 1965 to 1969 and the current population continues to grow. Although the population is still growing, it is thought that the growth rate is below the level at which a recolonizing population with suitable available habitat should be. In addition, northern southeast Alaska has a much lower growth rate than that of southern southeast Alaska (Gill and Burn, unpublished data). Reproduction is one of the possible factors controlling population growth. The overall goal of this project is to determine the reproductive strategies of sea otters in southeast Alaska to better understand the dynamics of the population. This will provide information that can be used as a vital component for accurately predicting population growth and can assist in determining what might be driving the lower than expected growth rates and the differences in northern and southern southeast Alaska. Knowing the dynamics of the population could ultimately lead to better management of the species. Specific objectives of this study include: (1) determine age at first reproduction and age-specific pregnancy rates, (2) determine morphometric changes based on age and reproductive state in both male and female sea otters, and (3) identify endocrine profiles and ovarian morphology to determine the different homeostatic reproductive states for sea otters in southeast Alaska. We will work with Alaska native subsistence hunters from throughout southeast Alaska to collect samples from subsistence-hunted sea otters. Sea otters are a keystone species, meaning they have a significant impact on their prey species and the structure of the entire community in which they live. Determining their reproductive strategies is a critical step in understanding the ecosystem dynamics and creating a more ecosystem-based approach to management. Defining reproductive characteristics of sea otters in southeast Alaska will provide valuable baseline data for modeling the population, assessing the effects of environmental changes, elucidating any differences between the northern and southern populations, and making crucial management and harvest decisions.

Steller sea lion entanglements and gear ingestion in Alaska and British Columbia

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Entanglement in marine debris and ingestion of fishing gear contribute to Steller sea lion (SSL; *Eumetopias jubatus*) injury and mortality. We surveyed SSL haulouts and rookeries throughout Southeast Alaska (2000-2012) and northern British Columbia (2000-2009) and documented sex/age class of animals entangled or that had ingested gear, and described the type of entanglement/ingested gear. We recorded > 500 individual SSLs that were entangled or had ingested gear including both males and females and all age classes. The most common neck entanglements were packing bands and black rubber bands. The most frequently ingested gear was salmon troll fishing gear, evidenced by flashers hanging from the corners of animals' mouths. During annual surveys of permanently marked (branded) sea lions, we documented 16 individuals that had ingested gear; a disproportionately high number (14) were males. Twelve branded animals (9 males, 3 females) had bands or line encircling their neck, face or head. We are tracking the fate of these known animals in order to estimate survival reduction caused by entanglement/ingested gear. It is likely that SSL entanglements will increase in coming years as debris from the Japanese tsunami enters Alaskan waters, highlighting the importance of this long-term monitoring effort. Reducing the use of packing bands, cutting loops of synthetic material, and re-configuring fishing gear that includes loops (e.g., black rubber bands used on crab pots) can prevent entanglements. We believe a cooperative effort between commercial and sport salmon trollers and biologists is needed to develop methods to reduce interactions between SSLs and salmon troll fisheries.

U.S. Navy funded marine mammal monitoring in the Gulf of Alaska 2011-2014

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The U.S. Navy's framework for marine mammal monitoring in the Gulf of Alaska will be presented. Regulatory permit drivers, ongoing monitoring and future monitoring through 2015 will be described. Ongoing monitoring in agreement with National Marine Fisheries Service (NMFS) includes deployment of two bottom-mounted high-frequency acoustic recording packages (HARP) from Scripps Institute of Oceanography. These devices were deployed on the shelf (200 m) and slope (1100 m) south of Seward, Alaska, in July of 2011. Data was recovered in May 2012, returned to Scripps for analysis, and the HARPs subsequently redeployed at the same locations for continued recording. Refinements in classification and analysis have benefited greatly from improvements identified from similar Navy-funded monitoring at other locations within the Pacific over the past eight years. A technical report on the Gulf of Alaska HARP analysis including species identification, seasonality, and identification of anthropogenic sounds will be presented by the Navy to NMFS in December 2013, and publically available by early 2013. New monitoring has also begun in 2012. A third Gulf of Alaska HARP was deployed offshore at Pratt Seamount (990 m) in September 2012. This HARP along with the previous two HARPs will have data retrieved in May 2013 for subsequent December 2013 reporting. In addition, the Navy is funding a vessel-based visual line transect survey within the Gulf of Alaska in the spring to summer 2013 time frame. This survey, similar to a Navy-funded one in 2009, will be conducted in association with NMFS to included visual transects, towed and sonobuoy passive acoustics, and where possible marine mammal biopsies and satellite tagging. Results from this survey should be available later in 2013.

Cortisol concentrations in phocid vibrissae to measure seasonal changes in stress

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Chronic stress can negatively impact animal health and reproductive success. Measuring seasonal changes in stress from wild phocids is difficult; requiring multiple samples collected during all seasons. This is especially difficult for some phocid species that spend up to 8 months in remote ice-covered locations. As an indicator of stress, we measured cortisol deposited into vibrissae. Previous studies indicate that phocid vibrissae grow continuously and shed annually. Because vibrissae are metabolically inert, cortisol concentrations measured in serial sections of vibrissae represent stress from distinct time periods during vibrissae growth. We examined cortisol concentrations in serial sections of harbor seal vibrissae (n=7) and found differences associated with season and cohort. Average cortisol concentrations for 5 vibrissae collected from adult harbor seals just prior to molt indicate the period at the root, representing winter (approximately December to May), had significantly more cortisol per mg vibrissae ($p=0.0004$) than the remaining sections, representing summer and autumn (approximately June to November). Additionally, we compared cortisol in whole vibrissae of 4 phocid species; spotted, ringed, bearded and harbor seals. Bearded seals had significantly more cortisol per mg vibrissae than ringed seals ($p=0.047$) and harbor seals ($p=0.0002$). Further research is needed to match the different levels of cortisol from the vibrissae sections to specific portions of the season; however, this method represents a single-sample collection that will greatly simplify measurements of seasonal changes in stress.

Impacts of sea otter predation on commercially important sea cucumbers in Southeast Alaska

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Sea cucumbers (*Parastichopus californicus*), which are an important commercial, subsistence and ecological resource, are negatively impacted by an expanding sea otter (*Enhydra lutris*) population in Southeast Alaska. Sea otters were reintroduced into Southeast Alaska in the 1960s after their demise in the 18th and 19th century fur trade; in the ensuing decades, the otter population grew, and sea cucumber biomass declined. This study evaluates the interaction and impacts of sea otters on sea cucumbers using sea cucumber foraging observations and survey data and sea cucumber density data collected for fishery management. Sea cucumbers represented about 5% of the sea otter diet. Declines in sea cucumber density ranged from 26 to 100% in areas with sea otters and were most severe within areas with high sea otter use. Sea cucumber density was lower in areas sea otters inhabited longer. The impact of sea otters should be included in sea cucumber fishery management as a step toward ecosystem based management and to ensure resource viability over the long term.

Juvenile survival and population trends of Steller sea lions at Chiswell Island, Alaska 1999 – 2012

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Juvenile survival was studied using a mark-recapture approach with 197 Steller sea lions branded as pups at the Chiswell Island rookery in 2005, 2007, 2008, and 2010. This rookery is part of the western distinct population segment which is currently listed as endangered under the ESA. Survival was affected by birth mass, sex, and age of the juveniles with males and younger age classes having lower survival rates. Cumulative survival from 3 weeks to 4 years of age was 39% for males and 57% for females. These rates were notably higher than survival estimates during the population decline in this region and similar to recent survival estimates for juveniles in the growing, eastern distinct population. Population counts were also conducted 1 to 4 times daily between mid-July and mid-September after the breeding season when the island was populated with post-breeding and non-breeding sea lions of all ages from surrounding areas. Numbers of age 1+ sea lions increased at an average rate of 6% per year between 1999 and 2012 ($r^2 = 0.845$, $P < 0.001$). Improved juvenile survival is also reflected in a significant increase of the proportion of young animals observed on Chiswell Island during the post-breeding season. These data reflect a mounting recovery of Steller sea lions in this area that began early in that last decade.

Range-use estimation and sighting probability for juvenile Steller sea lions (*Eumetopias jubatus*) in the Prince William Sound-Kenai Fjords region of Alaska

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Currently, it is not known how far juvenile Steller sea lions (SSLs) from the endangered western population range from rookeries within Prince William Sound, nor what the probability of sighting a sea lion may be within their core area, which often includes surveyed haul-out locations. Weaned (12-25 months) juvenile SSLs were captured in Prince William Sound or Resurrection Bay, Alaska, from 2001-2011. Data from 65 individuals fitted with external satellite-linked SDR-T16 or SPLASH tags (Wildlife Computers, USA) were analyzed to quantify the fine-scale movement patterns of sea lions using minimum convex polygon (MCP) and kernel density estimation (KDE) approaches to estimate both individual and group utilization distributions (UDs). From here, a multistate mark-recapture framework was applied to quantify terrestrial sighting probability and to develop a correction factor for count data. Initial MCP results indicate the total area encompassed by all study SSLs was 92,017 km^2, after accounting for land mass. While there was variation inherent within the KDE derived UD, in general the values were similar across individuals. 50% of the population fell within a range of 324-1,387 km^2 (mean=690.6 km^2, LCL=524.6 km^2, UCL=909.2 km^2 using a back-transformed 95% confidence interval). There were no significant differences in area use associated with gender or whether the juvenile spent time in captivity (seasonally adjusted $U = 124$, $p = 0.205$, $r = -0.16$ and $U = 87$, $p = 0.285$, $r = -0.13$, respectively). However, there were significant differences in seasonal area use: $U = 328$, $p = 0.011$, $r = -0.31$. There was no relationship between the UD area and the amount of time the tag remained deployed ($H(2) = 45.30$, $p = 0.698$). Comparison of haul-out usage within the multistate framework is currently underway.

Fatty acid composition of Steller sea lion (*Eumetopias jubatus*) milk

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Fatty acids have been used both qualitatively and quantitatively to investigate foraging ecology and diet within species and between species of many animals. Examination of milk fatty acids has shed light upon spatial and temporal variation in diets of several marine mammals. Milk was collected from the stomachs of recently suckling Steller sea lion pups to determine the fatty acid composition and changes over time in fatty acid composition of maternal milk within this species. Furthermore, variations in milk fatty acid profiles of lactating females with different attendance patterns were investigated. Milk samples were collected during the summers of 2010 (n = 7) and 2011 (n = 13) via gastric intubation from Steller sea lion pups on a small rookery in central Gulf of Alaska where individual females have been identified and their attendance patterns were observed via remotely operated video cameras. All sample processing was conducted at the Kodiak Seafood and Marine Science Center (UAF). Lipids were extracted using a modified Folch method and fatty acid methyl esters (FAME) were prepared from the extracted lipid. FAME were analyzed using gas chromatography (GC) techniques and fatty acids were identified via known standard mixtures and GC-mass spectrometry. A total of 56 fatty acids were identified in all milk samples. Hierarchical clustering and multivariate statistical techniques will be used to determine if milk fatty acids within the stomach degrade over time and if milk fatty acid composition differs between females known to have foraged post-perinatal period and those still in their perinatal period at the time of milk collection. Preliminary findings suggest differences between female groups in percentages of total polyunsaturated and monounsaturated fatty acids as well as 20:5n-3 (EPA) and 22:6n-3 (DHA) levels. This study adds to overall knowledge of marine mammal milk fatty acids and provides useful information about maternal investment in Steller sea lions.

Identifying humpback whale and sea bird prey using a submersible digital video camera

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We evaluated the feasibility of using low-cost submersible video cameras (GoPro Hero 2^{TM}) to identify humpback whale and seabird prey in situ. Non-invasive prey identification techniques for marine predators are generally limited to visual observation, sampling prey remains, or inferring prey type though hydroacoustics. The intent of this trial was to develop a system that is easy to deploy, could quickly identify subsurface prey during ship-based surveys, and verify acoustic targets. We deployed cameras using fishing reels when foraging whales and birds were encountered during line-transect surveys. The ability to rapidly deploy and retrieve the camera allowed us to capture ephemeral feeding events and identify dispersing prey. Although the camera was limited by depth, daylight, and turbidity, it supplemented our prey data with minimal disruption to surveys and other shipboard activities.

Behavioral and metabolic responses to simulated reduction in prey availability: Implications for physiological plasticity in pinnipeds

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Steller sea lions in Alaska have declined precipitously since the 1960s, and the Western stock is listed as Endangered under the U.S. Endangered Species Act. Localized competition with fisheries in areas where sea lions feed and reproduce has been identified as a potential factor in their decline and failure to recover, leading to restrictions in the 1990s on fisheries in areas identified as critical to sea lion feeding. However, sea lions in some areas have not recovered as expected, and some are still in decline. Climate change has been identified as a potential factor in that decline, and may be changing the distribution and abundance of prey species away from rookeries and haul out sites. As new hypotheses are proposed to explain the failure of the Western stock to recover fully, it is imperative that we improve our understanding of how sea lions respond behaviorally and metabolically to changes in the availability of their prey. These data can then be used to predict and monitor the effects of different impacts, such as different scales of fisheries harvest, climate change, and predator impacts. In this study we are examining behavioral and metabolic response to simulated changes in the prey field using captive trained California sea lions (*Zalophus californianus*) as a model for otariids. We expect reduced dive and foraging efficiency and increased metabolic costs under scenarios of reduced prey encounter rates and increased cost of swimming. Preliminary results suggest different responses between male and female sea lions.

Testing a passive deterrent on longlines to reduce sperm whale depredation in the Gulf of Alaska

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In Alaska, sperm whale depredation on longline sets has increased since implementation of the Individual Fishing Quota program in 1995. A collaborative effort (SEASWAP) has undertaken research to evaluate this depredation. A primary objective of SEASWAP was to develop and test a passive deterrent. The deterrent had to be safe, inexpensive, and easily deployed. We devised a deterrent using a 28 mm Lucite bead attached to the gangion. This sphere has a similar target strength (-28 dB) to blackcod, and is acoustically different than the control gear, the basis for the experiment, which tested the deterrent effect size during active sperm whale depredation on commercial longline sets. The study design included two factors with two levels: the presence or absence of sperm whales, and the presence or absence of the deterrent. Autonomous hydrophones deployed on the anchor line of the set recorded the creak/pauses of the whales (depredation indicators). Catch-per-unit-effort (CPUE) was used to test if the deterrent reduced the catch in the absence of whales. We conducted a bootstrap power analysis using data previously collected by SEASWAP researchers on sperm whale depredation of longlines. A total sample size of 24 longline sets (consisting of five 4-skate quads per set) predicted a statistical power of at least 0.90 assuming that the effect size was on the order of 2.5 creak/pauses per skate quad. The sampling unit is 4 skates (1 quad), enough gear to fill the water column during haul back. The deterrent treatment was randomized to the quads within the longline sets. A total of 24 successful sets were made during the experiment with 113 skate quads. Thirty-eight of the quads (33%) had whales present during haul back, 25 with beads and 13 without beads. Preliminary statistical analysis (t-test) of the beaded gear indicates that the CPUE of skate quads was not significantly different between the deterrent and the control groups (t statistic = 1.259, p-value= 0.2285). To date 18 quads have been analyzed to test the deterrent effect, yielding a preliminary non-significant result (t statistic = 0.301, p-value= 0.771). Final results will be presented.

Encounters between seagliders and adult female northern fur seals -- Linking biophysical variability to top predator behavior

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Behavioral responses by top marine predators to oceanographic features such as eddies, river plumes, storms, and coastal bathymetry suggest that physical interactions in these zones are potentially affecting the foraging and reproductive success of both the prey fields and predators themselves. Understanding the exact pathways by which this occurs has been hampered by the obstacles inherent in obtaining simultaneous observations of both environmental fields and predator behavior with resolution in the vertical as well as horizontal. In this study we present the results of satellite-tracked winter migration and diving behavior of 40 adult female northern fur seals (*Callorhinus ursinus*) from the Pribilof Islands in the Bering Sea, a population in decline for unknown reasons. Where possible, we compared these to oceanographic measurements collected from profiling Autonomous Underwater Vehicles off the coast of Washington State (USA), an important winter foraging ground for adult females. Adult females displayed a shift towards daytime diving after entry into the California Current ecosystem, and depth patterns of these dives suggest that adult females were feeding on prey aggregated immediately below the surface mixed layer (ML). Prey aggregation near the base of the ML is consistent with the hypothesis that females are required by their physiological dive depth limitations to winter in the coastal eastern Pacific, where ML depths are shallower and prey resources are more accessible. All three females with dive recorders who foraged near individual Seagliders showed evidence of this behavior. Two of the above animals also foraged near eddy edges, while a third spent 6 weeks in a productive Columbia River plume. Foraging near the edges of mesoscale features is also consistent with peaks in adult female alongshore distribution near coastal capes (eddy and filament generation sites), the Columbia River, and other inlets, and with a peak in cross-shore distribution 60-80 km from the shelf break, in a region of energetic mesoscale variability. The results of this study suggest that processes affecting ML depth, eddy generation, and vertical nutrient transport could all be important to winter foraging success of the adult female northern fur seal.

Implications of abduction: Estimating survival in temporarily captive endangered Steller sea lions

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Juvenile Steller sea lions (*Eumetopias jubatus*) have been the focus of more than a decade of research due to the dramatic population decline in the western stock. One of the unique approaches intended to maximize access to wild individuals included temporary captivity for research purposes at the Alaska SeaLife Center, in Seward, Alaska. However, it is important to understand how captivity may affect individuals before they can be used as an analog for the wild population. In a previous series of short-term behavioral and physiological studies, the potential effects, if any, of captivity on the study animals were examined. Here, we assess the long-term implications of captivity in the form of a survival comparison. Resights of 64 animals hot-branded prior to release, including both free-ranging and individuals housed in temporary captivity, were analyzed with the Cormack-Jolly-Seber method in the program MARK for estimating survival and resight probability based on sex, age, cohort and time-specific covariates. The two top significant models were found to equally explain the data ($\Delta AIC < 2$), where both showed time as a factor in the probability of resight. The top model suggested that survival was constant across time and sexes (survival probability, phi = 0.78), while the second best model showed a significant sex effect (phi_M = 0.75; phi_F = 0.80) survival ($\chi^2 = 0.975$, df = 1, p = 0.3234). Averaged survival rates, excluding age from model generation, show very similar numbers produced from wild survey studies and add to the confidence in the validity of temporary captivity. While work should be done to homogenize the resight effort, this initial analysis sets the stage for further work to evaluate the potential underlying physiological and behavioral factors associated with captivity. In turn, this may help to predict and evaluate survival outcomes within this endangered species.

Gulf of Alaska - Mammals

Cetacean seasonality in the Gulf of Alaska from passive acoustic monitoring

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The Gulf of Alaska is a challenging environment for conducting cetacean surveys due to its harsh weather conditions. Passive acoustic monitoring, which is not constrained by the weather, is an effective way to learn about the seasonal presence of cetaceans in these waters. Two High-frequency Acoustic Recording Packages (HARPs) were deployed in July 2011 within the Navy's Northern Edge Range in the Gulf of Alaska, one on the shelf and one on the shelf slope. Continuous, broadband (200 kHz sample rate) recordings were collected through February 2012. Presence of cetacean vocalizations was analyzed by manual and automatic scanning of the recordings. A large variety of cetaceans were recorded on the HARPs during all months. Blue and fin whales were commonly detected baleen whales. Three different blue whale calls were detected, including the northeast Pacific and the central Pacific tonal calls, and D calls. The central Pacific call was only detected during the summer, but the other two calls persisted into January. Fin whale 20 and 40 Hz calls were present during all months, with fin whale 20 Hz calls often dominating the entire low-end of the spectrum as a band of continuous noise that made it impossible to distinguish individual calls. This high level of calling presence indicates that the Gulf of Alaska is likely an important habitat for fin whales during the year. Humpback whale calls were more common during the fall and winter and persisted into February. Gray whale calls were detected once in late September, indicative of a migrating population. Echolocation clicks of three species of beaked whales were detected on the shelf slope site, mostly during the fall and winter. Stejneger's and Baird's baked whales were common, while Cuvier's baked whale was detected occasionally. The seasonality in their echolocation may indicate a seasonal migration. Sperm whale echolocation clicks were common at the shelf slope through early January. Killer whale calls were detected sporadically in recordings from both sites. Porpoises were very commonly detected on the shelf HARP and a few dolphins were detected there as well, but vocalizations from both groups were absent from the shelf slope.

Inferring vibrissae (whisker) growth in harbor seals (*Phoca vitulina*) using morphometrics

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Harbor seal vibrissae contain a temporal record of diet and stress that can be examined with stable isotope and cortisol analysis. Previous studies indicate that harbor seal vibrissae molt annually and regrow with an initial period of fast growth (~0.78 mm/day) followed by intermediate (~0.23 mm/day) and then much slower growth (~0.075 mm/d). Yet, another study on grey seals (*Halichoerus grypus*) found asynchronous vibrissae molt and inconsistent growth patterns. In order to interpret stress and diet analysis of vibrissae tissue on a temporal scale, a better understanding of molt timing and growth rates is necessary. We found that phocid vibrissae had a consistent morphology beginning with a smooth root section followed by a beaded sequence of peaks and troughs. We collected measurements of root length and distance between troughs and hypothesized that the smooth portion represented the slow growth period and the beaded portion represented the faster growth period. We examined vibrissae from different cohorts (adult male; n=28, adult female; n=32, juvenile male; n=32, juvenile female; n=58, male pup; n=76, female pup; n=55) of wild harbor seals live-captured during spring and summer in 2009 and 2010. Vibrissae molt is estimated to occur in spring; therefore we compared the length of the smooth root portion and found it to be longer in juvenile harbor seals captured in the spring than those captured in the summer. This supports the past finding that harbor seal vibrissae are molted in spring. Smooth root length was not different in adult seals comparing spring to summer suggesting that the vibrissae were not molted before the summer capture. We also measured distance between troughs on the beaded portions; this distance increased towards the tip for all cohorts in all seasons. These results suggest a decrease in rate of vibrissae growth from tip to root, and agree with the previous growth rates measured on harbor seal vibrissae. We believe that examination of vibrissae morphology, paired with other growth studies, will improve our ability to estimate vibrissae growth rates and timing of molt.

Below the surface: Using animal-borne tags to document fine-scale foraging of humpback whales in Sitka Sound, Alaska

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Humpback whales (*Megaptera novaeangliae*) are present in the waters around Sitka Sound, Alaska, during all months of the year. Whale numbers peak in fall and spring, concurrent with migrating to and from the Hawaiian wintering grounds. As a consequence of their massive body size and energetic demands, these animals require large quantities of densely-aggregated prey. It is necessary for these whales to consume sufficient food prior to migration because feeding does not occur in Hawaii. Upon returning to the feeding grounds, they need replenish their depleted energy stores. Situated on the edge of the Gulf of Alaska, Sitka Sound is a key habitat for this feeding aggregation offering opportunities for feeding at each end of the migration. Humpback whales have morphological adaptations unique among the filter-feeding baleen whales that increase their maneuverability and ability to capture a variety of prey types. To understand their fine-scale foraging behavior, we deployed 7 multi-sensor biologging tags on humpback whales in September 2012. We concurrently measured the distribution, abundance, density and identity of their prey with scientific echosounders and net tows. The tags continuously measure the depth, pitch, roll, heading, acceleration, and acoustics, allowing for unique insights into the diving and kinematic patterns associated with sub-surface feeding behavior of these whales. Our findings indicate that humpback whales target dense prey patches at depth. Whales were feeding continuously throughout daylight hours by lunging vertically up through the dense layers of krill (up to 50 m) in close proximity to the bottom. The whales executed up to 12 lunges per feeding dive, consistent with theories of optimal foraging. At dusk, their prey migrated vertically and dispersed within the upper 20 meters of the water column. Whales fed shallower and ultimately stopped feeding when prey levels fell below a threshold density for efficient feeding. These data represent the first sub-surface tag data on humpback whales from the Sitka Sound region, and will help inform ecological, conservation, and management studies on the species.

Using photogrammetry to estimate population demographics of Alaskan Steller sea lions (*Eumetopias jubatus*)

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Beginning in the mid-1970s, Steller sea lions (*Eumetopias jubatus*) experienced a precipitous 80% decline in abundance over a 25-year period across the range of the species, which is comprised of two Distinct Population Segments (DPSs). Though the endangered western DPS trend stabilized in 2000, the increases in abundance in the eastern two-thirds of the DPS have been offset by significant declines in the central and western Aleutian Island regions. While aerial surveys of terrestrial sea lion sites offer snapshots of abundance and population structure across the range, vital rate studies provide decadal estimates of survival and natality but are limited to a relatively small number of rookeries, leaving gaps in age-structured information—most notably in the central and western Aleutian Island regions. In this study, we used aerial images captured in the 2008 survey and developed photogrammetric methodologies to measure standard lengths of individual Steller sea lions. An altitude calibration flight was performed to correct for bias in altitude measurements collected from the radar altimeter and resulting regression equations were used to convert measured lengths (pixels) to "true" lengths (meters). Converted length-frequency data were applied to a finite mixture distribution model to estimate the proportion of the population comprised of three age-sex classes: juvenile males and females, adult females, and adult males. Broad regional comparisons were conducted for the western DPS and the two subregions experiencing contrasting abundance trends. Sea lions in close proximity to a pup or juvenile were indicated as such resulting in a model-independent index for "known" adult females. In summary, we found 1) within the western DPS, the increasing eastern sub-region had a higher juvenile proportion compared to the decreasing Aleutian Island regions; 2) model-derived adult female average lengths were not significantly different from "known" adult females; 3) adult females were found to be significantly smaller in the increasing eastern DPS than in the western DPS; and 4) females in the center portion of the western DPS range were larger than in the two fringing regions. Applying these methodologies to estimate age-structure dynamics could help identify population mechanics affecting the recovery of the western DPS in Alaska.

Predation risk of an upper trophic marine predator: Is Steller sea lion predation by transient killer whales greatest in areas of high utilization?

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Transient killer whales (*Orcinus orca*) (TKWs) are thought to hunt Steller sea lions (*Eumetopias jubatus*) (SSLs) near rookeries and haul-outs. The SSL is a central place forager that returns to shore-based locations (rookeries and haul-outs) to rest or provision young between foraging trips, condensing a temporarily pelagic distribution in 3D space while at sea to a periodic, heterogeneous distribution along a one-dimensional shoreline. Data received post-mortem from Life History Transmitter (LHX) tags implanted into 36 juvenile SSLs from 2005-2011 suggest high mortality by predation in the eastern Gulf of Alaska region. At least 14 of 16 detected mortality events were due to predation. We hypothesize that (H1) the spatio-temporal constraint of a central place forager leads to higher predation risk in areas of high utilization near rookeries and haul-outs. We will test our hypothesis by relating the location of mortality events detected from LHX tags to a density map of SSL locations. We will parameterize the utilization distribution using spatial tracking data from 73 juvenile SSLs tagged in Prince William Sound from 2003-2012 with externally mounted satellite transmitters. The Argos locations will be filtered and interpolated using a Bayesian switching state-space model to account for movement between offshore and onshore locations. The pelagic nature of most marine mammals inhibits the direct examination of foraging behavior and predator-prey interactions. This project will assess the possible impact of central place foraging on predation risk of juveniles from the western population segment.

Assessing the availability of glacial ice as habitat for harbor seals in a tidewater glacial fjord

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Tidewater glaciers are a prominent landscape feature along the southeastern and southcentral coasts of Alaska and play an important role in landscape and ecosystem processes. Many tidewater glaciers calve large icebergs into the marine environment which then serve as important substrate for harbor seals for resting, pupping, nursing young, molting, and avoiding predators. Although tidewater glaciers are naturally dynamic, most of the ice sheets that feed tidewater glaciers in Alaska are thinning and, as a result, many of the tidewater glaciers are retreating. The changes in available glacial ice may thus influence harbor seal populations; however, the relationship between ice conditions and harbor seal distribution and abundance are unknown. Our primary objectives are (1) to develop a semi-automated method for estimating ice cover and characteristics of glacial ice used by harbor seals from digital photographs collected during standardized surveys and (2) to assess the relationship between the availability of glacial ice and harbor seal spatial distribution and abundance. From 2007 to 2012, we conducted aerial photographic surveys (n = 43) of seals and glacial ice in Johns Hopkins Inlet, Glacier Bay National Park, Alaska, during the pupping (June) and molting (August) periods. Surveys were flown along a grid of 12 transects at an altitude of 1,000 ft. Non-overlapping digital photos were taken directly under the plane using a vertically-aimed camera. Preliminary estimates of seal (non-pups) abundance were consistently higher in June (range: 1,325 - 2,647) than in August (range: 1,041 - 1,928). The spatial distribution of seals was also much more extensive during June and corresponded to more extensive glacial ice coverage in the fjord. Future efforts will include developing quantitative estimates of ice cover, ice density, and seal density for inputs into habitat and geospatial models. Ultimately, understanding relationships between glacial ice availability and harbor seal distribution and abundance may provide novel perspectives on the spatial and temporal variation of harbor seals in tidewater glacial fjords.