



# Alaska Marine Science Symposium

JANUARY 16-20, 2012 • DENA'INA CENTER • ANCHORAGE, ALASKA



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

# 2012 Alaska Marine Science Symposium Book of Abstracts

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### **Interconnected Roles of the Arctic and Subarctic Oceans in Global Change: Challenges to Observation and Governance**

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The Arctic Ocean is changing extraordinarily fast, and to fully understand why requires that we examine its two-way interconnection with its neighboring subarctic Pacific and Atlantic domains and joint roles in global-scale hydrological and thermohaline cycles. A changing Arctic also acts back on the global system, with potential impacts on ocean currents and global precipitation patterns. By looking at and understanding the rapid and non-linear changes that taking place in the Arctic, we may develop potentially powerful tools to manage and cope with emerging global-scale issues. To demonstrate this point, results from the International Polar Year (IPY) – Canada’s Three Oceans project (C3O) and the Canada/U.S Joint Ocean Ice Study (JOIS) are presented as a case study to demonstrate the essential connectivities among the Arctic and subarctic oceans and to explore how changes within this coupled physical system are now impacting marine life and ecosystems, invasive species, ocean acidification and challenges to governance. These changes pose challenges that require cross-scale actions that will both aid in the advance detection of regime shifts and build resilience and transformative capacity within Northern communities coping with rapid change.

## Keynote

### Understanding Ecosystem Processes for the Eastern Bering Sea

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In 2007, the North Pacific Research Board (NPRB) and National Science Foundation (NSF) entered into a historic partnership to support a comprehensive \$52 million investigation of the eastern Bering Sea ecosystem to understand how climate change and associated changes in sea-ice are impacting this ecosystem and the consequences of these changes on lower trophic levels for fish, seabirds, marine mammals, and ultimately people. The partnership is now in its 6<sup>th</sup> year. The Program's vertically integrated biophysical model is running and providing interesting results. For example, multi-decadal (1970-2040) hindcasts and forecasts with a 10-layer biophysical (physics/NPZ) model of the Bering Sea indicate a significant negative correlation between the springtime water temperature and the fall biomass of large zooplankton. Another model product is the first BEST/BSIERP predictions for the seasonal and interannual distribution and growth of fish species based on daily oceanographic and production conditions. Both our model output and our observational program are providing new insights into the role of sea ice at many different trophic levels. BEST/BSIERP is also modeling how changing climate may affect how humans assess and use living marine resources. Climate scenarios for a management strategy evaluation (MSE) have been chosen and will be discussed. Our series of vignettes will showcase and build upon recent results from the Program, including those from the soon to be released special issue in *Deep-Sea Research II*. They will also demonstrate how the program has migrated from observation to synthesis.

## Keynote

### **The Gulf of Alaska Project: an Integrated Ecosystem Research Program**

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The Gulf of Alaska (GOA) Project is focusing on identifying and quantifying the key processes that regulate the recruitment of five commercially and ecologically important groundfish species. This study will investigate regional differences in ecological processes from southeast Alaska to Kodiak Island during spring, summer, and fall with comprehensive field sampling in 2011 and 2013. Field observations and laboratory analyses are being integrated through modeling and retrospective analyses. Speakers will comment on preliminary findings of species distribution, biophysical conditions in the GOA, and preliminary results from modeling and retrospective analyses.

**Keynote**

**TBA**

**Randy Olson**, [info@randyolsonproductions.com](mailto:info@randyolsonproductions.com), Randy Olson Productions

**Speakers: Arctic**  
*Ecosystem Perspectives*

**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 borders the eastern edge of the Central Channel and functions as a pelagic system, whereas the Burger study area lies south of Hanna Shoal and functions primarily as a benthic system. The Statoil study area, which is located near the boundary between the other study areas, has both pelagic and benthic attributes. Klondike tends to have lower benthic abundance and biomass and has 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. However, various water masses impinge onto all study areas seasonally and interannually, and patterns of sea-ice retreat vary interannually; in some years, much of the northeastern Chukchi is ice-free by mid-May, leading to pelagic blooms, whereas heavy ice cover in other years leads to within-ice production. These variations alter some of this pelagic-benthic dichotomy, and some aspects of this ecosystem suggest unusual structure.

**Speakers: Arctic**  
*Ecosystem Perspectives*

**An Integrated Chemical and Biological Study of the Benthos of the Chukchi Sea:  
Highlights from the COMIDA Program**

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The Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) Project is a comprehensive program funded by BOEMRE that is designed to establish an integrated knowledge of this biologically productive and diverse ecosystem. This component addresses the benthic system with a particular emphasis on sediment chemical characteristics and the benthic biota, both infaunal and epifaunal. Our studies confirmed that concentrations of potentially toxic metals were all below sediment quality criteria, with polycyclic aromatic hydrocarbons at background levels at 51 of 52 stations in our study area. Some higher trophic level invertebrates show promise as indicator species (e.g. the whelk *Neptunea heros*) which were observed to biomagnify organic contaminants and mercury. The sedimentation rate in this region is about 0.25 cm year<sup>-1</sup> but bioturbation is a dominant process in sediment turnover, and likely contributes significantly to the cycling of N and C, as reflected in active benthic fluxes of nutrients and gases measured in continuous flow experiments. Benthic infaunal populations and diversity was generally higher in the northern Chukchi, with sediment chlorophyll a, sediment grain size, food quality, and water mass depth as the most significant environmental variables. The epibenthic community was dominated by crustaceans and echinoderms, with organism size frequencies influenced by specific environmental parameters. The fauna within benthic communities generally fall within four trophic levels; stable isotopic data suggest that both phytoplankton and benthic microalgae are potential food resources. A web-based robust data management system has been developed to promote data sharing, synthesis and availability for public outreach at <http://www.comidacab.org>

**Speakers: Arctic**  
*Ecosystem Perspectives*

**Modeling the Eastern Chukchi Sea Food Web with Mass-Balance Approach**

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Several changes in arctic ecosystems have been attributed to climate change and many more are anticipated. Food-web models can improve our understanding of community structure and enhance our ability to recognize changes in ecosystem function. Presented here is a mass-balance food web model of the eastern Chukchi Sea which provides an annual snapshot of community structure. Species were represented individually where data permitted or were aggregated where data was sparse. The bulk of total system biomass is concentrated in benthic invertebrates and accordingly most of the mass flow above trophic level 2.0 was through this group. Mass flows to higher trophic levels through pelagic groups like zooplankton were an order of magnitude less. Arctic cod (*Boreogadus saida*) were the principal fish prey connecting production between lower and upper trophic levels. Additionally, we use a set of system metrics derived from a common modeling framework to highlight differences in ecosystem structure between the eastern Chukchi Sea and the nearby subarctic eastern Bering Sea and the more distant Barents Sea. The total biomass density ( $t\ km^{-2}$ ) of the eastern Chukchi Sea was nearly equal to the eastern Bering Sea but had only half the total production ( $t\ km^{-2}yr^{-1}$ ) and system throughput ( $t\ km^{-2}yr^{-1}$ ). The Chukchi was approximately double the Barents in total biomass density ( $t\ km^{-2}$ ), production ( $t\ km^{-2}yr^{-1}$ ), and throughput ( $t\ km^{-2}yr^{-1}$ ). A key distinction between the Chukchi and Barents community structure was the much more balanced distribution of biomass and associated flows between benthic and pelagic components.

**Speakers: Arctic**  
*Ecosystem Perspectives*

**A Conceptual Model for Determining Oil Fate and Effects on Habitat and Wildlife in the Arctic**

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Mary Campbell Baker, mary.baker@noaa.gov, NOAA Office of Response and Restoration

We developed a conceptual model to support planning for Natural Resource Damage Assessment (NRDA) from oil spills in the Arctic. The model describes habitats and taxa exposed, exposure mechanisms and injury to natural resources at the individual, population and ecosystem levels. For example, in the case of a release from an offshore platform in the sea ice-free season, one potential pathway for exposure is that oil that has risen towards the surface is entrained into the water column. This would expose the pelagic habitat. Taxa potentially exposed include zooplankton, ichthyoplankton, pelagic fish, seabirds and marine mammals. Exposure mechanisms could be ingestion, inhalation, adsorption and/or fouling. Injury to individuals could be manifested through oil toxicity and/or impacts of oil on behavior, respiration, growth, and reproduction. The model elements and examples are drawn primarily from the North American Arctic, but the principles and framework are likely to be generally applicable in other Arctic systems. We illustrate potential exposure and injury at the individual, population, and ecosystem level for one key taxa of the Arctic ecosystem, the Arctic cod (*Boreogadus saida*). The model can be used to prioritize NRDA data collection efforts pre- and post-oil spill, and identify key restoration projects. This prioritization is especially important in the Arctic where logistics are unusually challenging and may limit NRDA efforts. In addition, graphical representations of the model can be used to communicate damage assessment and restoration priorities to stakeholders and the public at large.

**Speakers: Arctic  
Humans**

**Updating the MAG-PLAN Alaska Economic Model**

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MAG-PLAN Alaska is a region-specific economic impact model used by the Bureau of Ocean Energy Management (BOEM; formerly the Minerals Management Service) to quantify potential economic impacts of oil and gas development in the Alaska Outer Continental Shelf (OCS) areas. MAG-PLAN Alaska is a Microsoft Access-based model that incorporates input-output methods. Northern Economics, Inc. and its subcontractors, Eastern Research Group and IMV Projects, were commissioned to update an existing model that was developed with information gathered in the Arctic IMPAK and Sub-Arctic IMPAK studies that were published in 2002 and 2003. Since that time, certain events or significant changes have occurred: shifts in prevailing oil and gas prices, renewed industry interest in OCS development, proposals to commercialize and transport stranded North Slope gas to markets, as well as changes in technology, that warrant an update of the MAG-PLAN Alaska model. The updated MAG-PLAN Alaska model:

- Incorporates new oil and gas industry data as well as more region-specific information on spending patterns;
- Allows better distinction among the different Alaska offshore planning areas in the model;
- Adds the ability to estimate effects of significant gas production and transportation; and
- Provides software fixes to address issues that BOEM has encountered in using the prior model.

The presentation provides information on new technologies, industry costs, and manpower requirements for various offshore exploration, development, and production activities, as well as information about the enhanced features of the model.

**Speakers: Arctic**  
*Humans*

**Building a Framework on How to Assess Food Security in the Alaskan Arctic**

**Carolina Behe**, carolina@iccalaska.org, Inuit Circumpolar Council - Alaska

The Inuit (Inupiat and Yupik) have called the Alaska Arctic home for at least the last 10,000 years. Their daily lives, culture, language, food and overall survival have been shaped by the world around them and in turn are an intricate part of that environment, playing a strong and important role. The Arctic environment is changing quickly; the changing environment is affecting the marine and terrestrial life which the Inuit rely on, ultimately affecting food security. Recent years have seen an increase effort in biodiversity monitoring, climatologically and oceanography data collection, and so on from the many stakeholders taking interest in the Arctic. Yet, little is linking this research together or to the human dimension. Meeting the formidable challenges brought on by climate change, a changing environment and increased industry, requires an enhanced understanding of the human dimension and its role in the food web. The objective of this project is to launch an initiative to investigate how to evaluate food security in the Alaskan Arctic, to draw together multiple sources of knowledge, and incorporate the human dimension in order to increase understanding of the Arctic. The project will be enacted over a two year period and entails a synthesis and analysis of Arctic research to identify gaps which inhibit understanding of food security and the human dimension, and working closely with Arctic communities.

**Speakers: Arctic**  
*Humans*

**Climate Change and Subsistence Fisheries in Northern Alaska**

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Given current and projected warming trends in the Arctic and the dependence of northern communities on subsistence-based ways of life, it is increasingly important to understand local observations of climate change and their impacts on subsistence practices. This paper provides the results of two ethnographic studies based on interviews and participant observation of local changes experienced in subsistence fisheries in the Northwest Arctic and North Slope Boroughs. The data suggest that residents in both regions are currently observing environmental changes that have significant implications for their subsistence practices. In northwest Alaska, elders and expert fishermen in Noatak, Selawik, and Shungnak identify several salient changes, including: lower water levels, changing fish abundance, shifting weather patterns, increasing beaver abundance, and changes in the timing of fish migrations. These changes have a range of impacts on subsistence fisheries affecting accessibility, safety, and the processing and storage of fish. Using cultural consensus analysis, we discuss the level of agreement about these observed changes and their impacts within and between communities. In the North Slope region, fishermen in Barrow and Nuiqsut observe similar changes and impacts, as well as a growing abundance and wider distribution of various Pacific salmon species. Emerging subsistence salmon fisheries have generated new patterns of fish harvest and consumption, as well as concerns about outside interest in commercial fisheries development. Informants in both regions frequently mention the effects of changing lifestyles and culture on subsistence practices, suggesting that climate change is but one factor of a "total environment of change" being experienced in Inupiaq communities in Arctic Alaska.

**Speakers: Arctic**  
*Climate & Oceanography*

**First Results and Future Needs for Small Unmanned Aircraft Operations  
from Icebreakers in the High Arctic**

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For the first time small unmanned aircraft systems (SUAS) were flown and recovered from icebreaking ships in the arctic, within 100 miles of both the true and magnetic North Pole. The 4.2lb RQ-11A "RAVEN" SUAS, used extensively by the military, includes standard and infrared video systems which transmitted to video terminals on the ships' bridge. The RAVENS were hand launched and retrieved with <1hour endurance and <10kilometer range. Nighttime IR imaging was particularly successful for ice ridge detection. Ice imagery was used for locating autonomous underwater vessel (AUV) launch/recovery sites, polar bear watches for on-ice teams, and to guide the ship, saving fuel and time. RAVEN imagery can be integrated into the US Coast Guard icebreaker HEALY's MapServer, which overlays satellite ice images, bathymetry, and science stations so scientists and ship drivers can optimize cruise planning. Using the SUAS for ice reconnaissance avoids the time, cost and risk of using manned helicopters, and the cost, time delays and resolution limits of satellite ice imagery. These SUAS are a cost effective measure can also be used to evaluate critical habitats for marine mammals including ice seals, which vary in their preference for different ice ridge habitats. Icing of UAS imager lenses occurred in fog, and methods to remedy airframe and imager ice-up will be required to optimize use of unmanned aircraft for research and reconnaissance in the arctic. AUV overflight by the UAS was accomplished, and in future could include AUV-to-UAS communication. Additional icebreaker unmanned aircraft operations are planned for 2012.

**Toward Producing a Beaufort/Chukchi Seas Regional Reanalysis**

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Ongoing oil development in the Beaufort/Chukchi Seas is accompanied by the potential threat of oil spills. In the event of a spill, time is of the essence in directing mitigation efforts, and thus improving the predictability of oil spill transport is of great importance. As the surface wind field is the primary factor in driving ocean currents, and thus the dispersal of any accompanying oil, accurate modeling of the surface winds is essential in enhancing the prediction of oil spill transport.

In this study, the Weather Research and Forecasting (WRF) model and its variational data assimilation system were used to conduct numerical simulations of the region's mesoscale meteorology at a grid spacing of 10 km. To optimize the model configuration for the study domain, various assimilation approaches have been attempted, using different assimilation packages, background error computations, and combinations of observation types, including both in situ and satellite, with varying degrees of success. In addition, the use of various sea ice, snowcover, and SST datasets to modify the lower boundary conditions has been explored. The results of these tests are presented, demonstrating the successes and failures of the different approaches in the study region, and documenting the process undertaken to finalize the model configuration. Following testing, a 5-year (2005-2009) reanalysis was produced with the optimized model and assimilation configuration. The reanalysis demonstrates significant improvements in representing surface conditions, particularly surface winds, relative to those given in ERA-Interim, to this point the most accurate reanalysis available over the study domain.

**Speakers: Arctic**  
*Climate & Oceanography*

**Circulation in the Northeast Chukchi Sea Depicted by Oceanographic Moorings and HF Radar**

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We present data from shore-based, high-frequency radars (HFR) that map the surface circulation along with year-long acoustic Doppler current profiling records and temperature and salinity measurements collected from oceanographic moorings. The HFR data are obtained during the ice-free seasons of fall 2010 and summer 2011. The moored time series derive from an array of 6 moorings, each separated by ~13 km and distributed across a 65 km wide transect extending northwestward from the 30 m isobath. The transect includes the Alaskan Coastal Current and the Chukchi shelf southeast of Hanna Shoal. Moored data includes hourly observations of all variables from fall 2010 through late summer 2011. In aggregate the data describe the seasonally-varying circulation at the head of Barrow Canyon in the Northeast Chukchi Sea. Under southerly or mild easterly winds the flow across the mooring array includes water moving eastward from the central Chukchi shelf and merging with coastal water flowing northeastward along the Alaskan coast. Under strong northeasterly winds the flow reverses and, on occasion, includes upwelled waters from deep within Barrow Canyon. We show the time-varying horizontal and vertical structure of the flow field and how it varies with winds, ice-cover, and stratification. We characterize the synoptic and seasonal variations in the currents and the transport, and quantify the predictive skill between transport and winds. We conclude by examining how transport variations near the head of Barrow Canyon vary in conjunction with transport variability in Bering Strait.

**Chukchi Acoustics, Oceanography, and Zooplankton (CHAOZ): Observations on Chukchi Sea**

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In August 2010 and 2011, the CHAOZ cruises measured temperature, salinity, nutrients, chlorophyll, oxygen and PAR, and collected zooplankton samples along five eastern Chukchi Sea transects. In addition, three arrays of passive acoustic and oceanographic moorings were deployed (2010 and 2011) and recovered (2011) at 80, 140, and 230 km offshore of Icy Cape. Moorings were deployed for a year, with 7-8 moorings in each array. Moorings measured temperature, salinity, PAR, fluorescence, currents, ice thickness, oxygen, turbidity and nitrate. One mooring contained an active acoustics device (Tracor Acoustic Profiling System, TAPS-8) quantifying zooplankton biomass and size distribution. Ice arrived over the moorings in late October/early November 2010 and persisted into June. Measured variables on the moorings responded to presence/absence of ice. Annual average currents were strongest nearshore (~7 cm/s) and decreased offshore to ~5 cm/s. Bottom temperatures were warmest at the end of October (~4°C), cooled to the freezing point shortly after ice arrival, and began warming with ice retreat. Elevated fluorescence occurred in September, but highest fluorescence was observed in June-July. In summer, the shelf evolved into two-layer system with nitrate drawn-down or depleted through most of the water column, but with elevated ammonium concentrations (~4-6 uM) in the bottom layer. During the two cruises, zooplankton volume backscatter was highest at the surface and at depth with lowest values in the middle of the water column. Krill were not observed in the samples collected in 2010, but were found on some transects in 2011.

**Speakers: Arctic**  
*Lower Trophic Levels*

**A Long-term Census of the Zooplankton Communities in the Pacific Arctic**

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The highly productive Chukchi Sea shelf is a complex gateway into the Arctic, on which climate variation may have a profound impact. We examined summer zooplankton community structure in the Arctic waters between Alaska and Russia from the Bering Strait northward to Wrangel Island during 2004, 2009 and 2010 within the ongoing RUSALCA (Russian-American Long-term Census of the Arctic) program. We also accessed secondary production by conducting egg production experiments on some of the most abundant copepod genera (*Pseudocalanus* spp., *Metridia* spp.), which have both Arctic and Pacific members. The total abundance and biomass of holozooplankton varied significantly across the area and between the years, averaging 3500 ind m<sup>-3</sup> and 42 mg DW m<sup>-3</sup> in 2004, 8250 ind m<sup>-3</sup> and 78 mg DW m<sup>-3</sup> in 2009, and 9700 ind m<sup>-3</sup> and 69 mg DW m<sup>-3</sup> in 2010, all based on 150 µm nets collections. The species composition also varied significantly; we encountered a total of 68 holoplanktonic species in the region, as well as a wide variety of meroplankton, which also contributed notably to community biomass and abundance. In contrast, temperature-adjusted reproductive rates showed little difference between years. Several major assemblages of zooplankton were identified using multivariate analysis and tied to distribution of the water masses present in the region.

**Inter-annual Variability of the Planktonic Communities in the Northeastern Chukchi Sea: 2008-2010**

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The planktonic communities of the northeastern Chukchi Sea were surveyed as part of a multi-year, interdisciplinary baseline study supported by ConocoPhillips, Shell Exploration and Production and Statoil USA Exploration and Production companies. Chlorophyll-a, inorganic macronutrients and zooplankton (150µm and 505µm nets) were sampled along two 900 NM<sup>2</sup> grids (Klondike and Burger) at high spatial resolution three times per ice-free season in 2008 and 2009, with a third grid (Statoil) added in 2010. The 2009 season saw an earlier retreat in seasonal ice cover and warmer SSTs over the region than recorded in 2008, while 2010 appeared intermediate between the two. The spring bloom was partially captured in 2008 and 2010, but not in 2009, with low concentrations of nutrients and chlorophyll observed post-bloom. Eighty taxonomic categories of zooplankton, including 11 meroplanktonic categories, were observed with greatest diversity found within the copepods (25 species), followed by the cnidarians (11 species). All species are typical for the region and are of sub-arctic Pacific origin. A seasonal evolution of the community structure was apparent over each survey area where cold oceanographic conditions in 2008 slowed growth and development of the zooplankton, and in 2009 the early bloom supported a moderate-biomass zooplankton community. In 2010, the combination of environmental factors supported the largest zooplankton community. Biomass changes were driven by increases in large-bodied lipid-rich copepods important for higher trophic levels. Inter-annual differences in ice-melt timing, water temperatures, northward transport of water masses, nutrients and chlorophyll thus create a region with highly variable pelagic productivity.

**Speakers: Arctic**  
*Lower Trophic Levels*

**Benthic Fauna of the Northeastern Chukchi Sea, 2008-2010**

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In 2008 to 2010, an interdisciplinary study evaluated benthic communities in the vicinity of three proposed oil and gas exploration areas (Burger, Klondike, and Statoil) in the northeastern Chukchi Sea. This study was sponsored by ConocoPhillips, Shell Exploration and Production Company, and Statoil USA E & P to collect information on the ecosystem in these areas prior to exploration and provide environmental data useful for permit applications and post-development comparisons. Sediment-dwelling macrofauna and megafauna were collected at up to 82 sites with a van Veen grab in August, 2008 to 2010, and up to 37 sites with a plumb staff beam trawl in 2009 and 2010. The fauna found in 2008 to 2010 were numerous and large. Abundance, biomass, and the number of taxon found were significantly higher in the Burger study area as compared to Klondike, with the Statoil area reflecting intermediate values. Spatial variations were associated with physical gradients and temporal variations with oceanographic conditions reflecting climatic variability. These results indicate strong associations of benthic communities with seafloor geomorphology and environmental gradients, as well as water column characteristics.

**Epifaunal Communities in the Alaskan Beaufort Sea**

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Arctic epibenthic communities can represent an important fraction of the total benthic biomass and add significant diversity to the benthos. From an ecosystem perspective, they are important in recycling and redistributing organic matter deposited from the pelagic zone as well as key elements in the local food web. The increasing economic interest in the Beaufort Sea stresses the need to expand our knowledge and understanding of the regions epibenthic community composition and distribution and of their controlling environmental variables. With this purpose, biological (epibenthic species composition, abundance and biomass) and relevant environmental data (bottom water temperature, salinity, pH, sediment grain size, chlorophyll and organic matter, depth and station coordinates) were collected at 73 stations in the eastern, central and western Alaskan Beaufort Sea shelf, in August of 2011. Significant spatial variability was observed in community composition and dominant taxa throughout the study area. Echinoderms and crustaceans were the dominant taxa in terms of biomass and abundance, yet molluscs had the highest diversity. In general, biomass was highest at the western stations and lowest at stations in the east, averaging  $22.9 \pm 41.4$  s.d. kg and  $6.7 \pm 7.5$  s.d. kg per trawl, respectively. However, mean diversity was nearly the same for these two areas,  $27 \pm 9$  s.d. taxa at western stations and  $28 \pm 6$  s.d. taxa at eastern stations. Environmental drivers are yet to be included in this analysis.

**Speakers: Arctic**  
*Fish and Fish Habitat*

**Genetic Investigation of the Population Structure of Arctic Cod**

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Arctic Cod (*Boreogadus saida*) plays a foundational ecosystem role in arctic and boreal marine waters. Despite its ecological importance and the possibility of commercial exploitation, little is known about the species' population size and structure. Here we report preliminary analyses of mitochondrial and nuclear DNA to examine the population structure of *B. saida* across its range from the western North Atlantic to the eastern North Pacific. 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). We uncovered little evidence of differentiation within the eastern group but sample sizes were too low to be conclusive. Within the western group, the Beaufort Sea sample is differentiated from samples collected in the Chukchi and Bering seas ( $P = 0.03$  and  $0.02$  respectively); the signal of this differentiation is not strong, as  $F_{ST}$  between the Beaufort and the Chukchi and Bering Sea samples is not significant ( $P$ -values  $0.28$  and  $0.1$  respectively). Mitochondrial DNA analyses corroborate a signal of differentiation between the Beaufort and the Chukchi samples ( $F_{ST} = 0.043$ ,  $P = 0.018$ ), but not east-west differentiation ( $F_{ST} = 0.017$ ,  $P = 0.073$ ). These preliminary analyses suggest that *B. saida* is not genetically homogeneous across its range from the North Atlantic to the North Pacific, and further investigation is warranted. Understanding genetic variability and population structure of pivotal species such as Arctic Cod is an essential aspect of management and conservation of marine ecosystems.

**Speakers: Arctic  
Seabirds**

**A Standardized Method for Identifying Important Bird Areas for Marine Birds Using At-Sea Survey Data**

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Effective seabird conservation requires knowledge about the areas that are most important for foraging in the breeding and non-breeding seasons, and for stopover sites in-between. The patchy and ephemeral distribution of pelagic seabirds makes identifying important sites challenging, and previously there has been no standard method for identifying and mapping such areas. Using over 30 years of at-sea survey transect data, we developed a spatial analysis method for identification of marine Important Bird Areas (IBAs). Our method included filters to check for adequate survey effort, persistent species presence, and adjacency. Averaged transect densities were used for kernel density analysis which yielded the final map of marine hotspots for each species studied. We then drew IBA boundaries around areas that exceeded a globally significant density threshold, and validated those boundaries using the extrapolated survey counts resulting from kernel density analysis. We conducted a final cross-check using seabird colony counts to judge the reasonableness of the identified pelagic foraging areas. Finally, we built a geospatial processing tool to automate the analysis of IBAs and to make our methods accessible to other seabird biologists. Our tools and research integrated data along the entire Pacific coast from the U.S. Beaufort Sea to Baja California, Mexico, and are being used to help set national and international standards for marine IBA identification.

**Speakers: Arctic  
Seabirds**

**Influence of Water Masses on the Seabird Community of the Northeastern Chukchi Sea**

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We examined relationships between oceanography and the distribution and abundance of seabirds in the northeastern Chukchi Sea in 2008-2010 as part of a multi-year, interdisciplinary study (Chukchi Sea Environmental Studies Program) supported by ConocoPhillips, Shell Exploration and Production Company, and Statoil. We conducted boat-based surveys in 3 study areas located in the offshore northeastern Chukchi Sea known as Klondike, Burger, and Statoil. The total density of seabirds was considerably higher in 2009 than it was in 2008 or 2010 and generally was higher in Klondike than in Burger in 2008 and 2009; densities did not differ significantly among Klondike, Burger, and Statoil in 2010. Species-composition varied among study areas, seasons, and years. The numerical dominance of alcids in all study areas combined increased from 2008 to 2010. Klondike was numerically dominated by alcids and tubenoses in all years, whereas Burger was numerically dominated by larids and tubenoses in 2008 and by alcids in 2009 and 2010; Statoil also was numerically dominated by alcids in 2010. The distribution of seabirds, particularly the planktivorous species, may be influenced by advective processes that transport oceanic species of zooplankton from the Bering Sea to the Chukchi Sea. This transport differed among years and resulted in a broader northeastward intrusion of Bering Sea Water, higher abundance of large oceanic copepods and euphausiids, and greater abundance of planktivorous seabirds in both study areas, in 2009 than in 2008 or 2010.

**Shifting Prey in a Melting Arctic: Breeding Seabirds Adapt to the Loss of Summer Ice**

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Reduced sea ice extent and increased water temperatures were associated with decadal-scale prey switching at a northern Alaska Black Guillemot (*Cepphus grylle*) colony. From 1975 to 2002 guillemots on Cooper Island provisioned nestlings almost exclusively with Arctic Cod (*Boreogadus saida*) but starting in 2003 the frequency of sculpin (*Myoxocephalus* spp.) in the diet increased, correlated with increasing distance to the pack ice. Sculpin now are the primary prey for most of the 20 July - 10 September nestling period. Until 2011, the appearance of sculpin in the chicks' diet was associated with colony-wide decreases in nestling growth rates and increased nestling death. In 2011, however, over half of the nesting pairs maintained high nestling growth rates when prey switched from Arctic Cod to sculpin in early August. Nesting failures associated with a switch to sculpin in earlier years may have been due to low sculpin abundance or availability caused by unfavorable oceanographic conditions. In 2011, after the switch to sculpin, growth rates of nestlings decreased on days of decreased water temperature. The ability of some, but not all, guillemot pairs to maintain nestling growth after the prey switch in 2011 apparently reflects individual variation in adaptability to short-term changes in prey type. High breeding success in 2011 demonstrates that Black Guillemots can persist in arctic Alaska despite the loss of summer ice by switching from ice-associated prey to benthic prey. The ongoing studies at the Cooper Island colony should assist in monitoring anticipated northward expansion of subarctic fish into the Beaufort Sea.

**Speakers: Arctic**  
*Mammals*

**Ringed and Bearded Seal Populations in Alaska Are Not Showing Signs of Decline**

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The Alaska Department of Fish and Game (ADF&G) has been monitoring the health and status of ringed (*Phoca hispida*) and bearded (*Erignathus barbatus*) seals in Alaska since 1960 by collecting information and samples from the Alaska Native subsistence harvest. We examined how parameters that affect population size and status vary in time and how current conditions compare with past conditions. These data span five decades and include time periods well before changes in sea ice or other factors attributed to climate change were present. Compared to past decades, ringed seals have similar blubber thickness, but are growing faster, maturing younger, and have higher pregnancy rates. The proportion of pups in the harvest is also currently higher. For bearded seals, age at maturity has not changed, but blubber thickness and pregnancy rates are higher than in the past. The proportion of pups in the harvest is similar to that of the 1970s and twice as high as the 1960s. The number of pups in the harvest of both species indicates that pups are surviving beyond weaning, and responses to hunter questionnaires indicate that ringed and bearded seal numbers have not decreased. Stomach contents indicate that ringed and bearded seals currently consume more fish and fewer invertebrates than in the past. Taken as a whole, we found no evidence that ringed or bearded seal populations in Alaska are declining or that current conditions are more stressful than those in the past.

**Speakers: Arctic**  
*Mammals*

**Histopathological and Ancillary Diagnostic Findings from Seals and Walrus in the  
2011 Disease outbreak in the Arctic**

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Starting in July 2011, higher than normal numbers of ringed seals were observed hauling out on the beaches along the North Slope of Alaska. Some seals exhibited multiple skin lesions including ulcers around the nose, eyes, neck and hind flippers as well as patchy hair loss. Some were lethargic and had labored respiration and some mortality occurred. Similar cases were also reported from Canada and Russia in ringed seals. Walrus exhibited a similar ulcerative skin disease. Most affected walrus appeared healthy, however there were associated mortalities. Various biological samples were obtained for analysis from both seals and walrus. Extensive diagnostic testing was performed. Significant histopathologic lesions were present in skin, respiratory system, liver, lymphoid system, heart, and brain. The epidemiology and pathology of clinical disease and lesions suggest a viral etiology, including ballooning degeneration and possible inclusion bodies in the skin, and mononuclear hepatitis. Bacterial cultures yielded various isolates from lesions and internal organs; these microbes were considered post mortem invaders or secondary opportunists. Superficial fungal involvement in ulcers was noted microscopically. Representative samples from ulcers and viscera were inoculated into multiple cell lines for virus isolation. Characterizations of possible virus isolates are underway. Electron microscopy has not demonstrated viruses and polymerase chain reaction (PCR) has been negative for Calicivirus, herpesvirus, canine distemper virus, and phocid morbillivirus. Serology has not revealed consistent increased titers to *Leptospira* or morbillivirus. Although a definite agent has not yet been identified, efforts are ongoing with microarrays and additional studies to define a potential pathogen.

**Speakers: Arctic**  
*Mammals*

**Marine mammals and Sea Ice Loss in the Pacific Arctic:  
Tracking Ecosystem Responses to the -New Normal- During a Period of Rapid Change**

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Recent late summer sea ice retreats are influencing the phenology of marine mammals in the Pacific Arctic. Extreme sea ice retreats negatively impact ice-obligate marine mammal species, but may provide access to new foraging habitat for temperate species. For example, walrus haul out by the thousands in late summer along the NW Alaska coast, while summertime reports of harbor porpoise, humpback and fin whales in the Chukchi Sea suggest these temperate species now routinely occur there. In 2010, satellite tagged bowhead whales from Atlantic and Pacific populations met in the Northwest Passage, an overlap thought precluded by sea ice since the Holocene. Extensive nearly ice-free regions now occur each year in the Pacific Arctic sector, with record low sea ice extents in 2007 and 2011. Sea ice thickness continues to decrease, while autumn temperatures increase, suggesting that the Arctic climate system may have reached a 'New Normal'. As keystone species of marine ecosystems and indigenous culture, marine mammals provide a nexus for research, cross-cultural dialogue and public engagement. The goals of two new projects, the Distributed Biological Observatory (DBO) and the Synthesis of Arctic Research (SOAR), include the tracking of marine mammal responses to ecosystem shifts associated with sea ice loss. While both projects face challenges associated with communication across scientific disciplines and cultures, an overarching goal is to identify "New Normal"™ patterns for marine mammal populations as a foundation for the development of predictive scenarios to support integrative scientific research, local response and adaptive management.

**Speakers: Arctic**  
*Mammals*

**Acoustic Detections of Pacific Walrus in the Northeastern Chukchi Sea, September 2007 to July 2011**

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A passive acoustic monitoring program sponsored by Shell Exploration and Production Company, ConocoPhillips and Statoil USA E&P has been in place in the northeastern Chukchi Sea since July 2006 to monitor natural and anthropogenic ambient sound levels and to survey marine mammals. Pacific walrus are targeted by this program to assess their potential interactions with nearby oil and gas exploration activities and the effect of the recent decline in sea ice. Here we report on walrus acoustic detections from September 2007 to July 2011. The results are based on the manual review of 5% of the data combined with automatic processing (using auto-detectors) of the entire dataset. These analyses produce estimated call counts for each station, thereby providing information about walrus' relative abundance throughout the study area. Walrus typically entered the study area in the spring during the first half of June. They were broadly distributed from July to September although Hanna Shoal and its southern edge concentrated the highest number of call detections and, presumably, the highest animal densities. Large numbers of calls have been detected inshore at Point Lay (2010) which coincides with the observation of large haul-outs in this area. The Cape Lisburne area appears to be both a haul-out site and the exit gate for walrus leaving the Chukchi on their way to the northern Chukotka coast. Acoustic detections typically start to decline during the second half of September. Walrus are only sporadically heard past mid-October. The latest winter detection occurred on February 27 in 2011.

**Speakers: Arctic**  
*Mammals*

**Acoustic Presence of Bowhead Whales at an Offshore site in the Chuckchi Sea Compared with Nearshore Visual Observations of the Spring Migration Past Point Barrow, Alaska**

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Abundance estimates of the Bering-Chukchi-Beaufort (BCB) stock of bowhead whales have been undertaken repeatedly since the 1970's and rely primarily on visual observations from ice-based and aerial surveys. The timing of the spring migration of this stock has been well documented and occurs between early April and late May of each year. During this time, three pulses of animals pass Pt. Barrow. We collected acoustic recordings between 2007 and 2010 120km north-northwest from Pt. Barrow and analyzed them for the presence of bowhead whale calls to assess the possibility that some portion of the BCB bowhead population may utilize areas farther offshore and outside of the detection range of visual surveys during the spring migration. We present the four-year seasonal occurrence of bowhead whale acoustic detections between September and June with a special focus on the spring migration periods. Where possible, the spring detections are compared to ice-based and aerial survey daily sighting rates, as well as traditional ecological knowledge of the migration. Bowhead whale acoustic detection rates were highest in each year from mid to late May and into June. This is later than typically encountered nearshore, suggesting that some portion of the population may utilize offshore areas during the spring migration. Detections are also compared to sea ice cover at the study site and to nearshore lead width in order to investigate the role of ice cover and lead width in the selection of offshore rather than nearshore areas for migration.

**Speakers: Arctic**  
*Mammals*

**Exposure to Seismic Operations Affects Bowhead Behavior and Sightability in the Alaskan Arctic**

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Aerial surveys are conducted in the Beaufort Sea during late summer and fall to monitor the effects of oil and gas exploration on the distribution of bowhead whales (*Balaena mysticetus*). Earlier analyses showed that bowhead whales exposed to seismic survey activities in the Beaufort Sea exhibited localized displacement and altered surface-respiration-dive behaviors. The objective of our study was to quantify how changes in surface-dive behavior associated with exposure to seismic sound influence the detectability of whales during aerial surveys. Altered detectability resulting from these changes in diving behavior could lead to under- or overestimates of the numbers of whales present as well as to incorrect conclusions about their distribution relative to seismic operations. We applied Linear Mixed Models to behavioral data collected by government and industry aerial observation programs from 1980 to 2000 to investigate the effects of seismic disturbance on surface-dive behavior. We assessed the influence of seismic sound on whales according to reproductive state, activity, and season. Our results confirm that exposure to seismic sound affects bowhead surface-dive behavior and whale detectability. Surfacing times significantly decreased when whales were exposed to seismic sound, as did the overall mean proportion of time at the surface, particularly in fall, and while whales were engaged in travel and feeding activities. Analyses of bowhead whale sightings from aerial surveys to estimate abundance and distribution must thus apply availability correction factors appropriate to the sound exposure, whale status, and whale activity.

**Speakers: Arctic**  
*Mammals*

**Western Arctic Bowhead Whale Movements and Habitat Use throughout their Range:  
2006–2011 Satellite Telemetry Results**

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In 2005, the Alaska Department of Fish and Game began a cooperative research project to study movements and habitat use of the western Arctic stock of bowhead whales (*Balaena mysticetus*). In collaboration with the Alaska Eskimo Whaling Commission, the North Slope Borough, the Greenland Institute of Natural Resources, and the Department of Fisheries and Oceans Canada, with core funding from the Minerals Management Service, 59 satellite transmitters were deployed on bowhead whales in Alaska and Canada between 2006 and 2010. The majority of the whales were instrumented in waters near Point Barrow, Alaska, and near the Tuktoyaktuk Peninsula in Canada by Native subsistence whalers. Six tags have transmitted for more than a year, allowing a complete description of annual movements in the Bering, Chukchi, and Beaufort seas. Thirty tags have transmitted for more than three months covering significant portions of the annual migratory cycle. Tagging in consecutive years has allowed us to examine variability in movements, wintering areas, and the timing of migration among years. We have identified several areas of concentrated use throughout the range of bowhead whales, and have documented interactions with industrial activities and potential conflicts with shipping. We plan to begin tagging near St. Lawrence Island, Alaska to investigate whether the location of tagging is a factor in bowhead movements. Future analyses include bowhead movements relative to industrial activities and oceanographic factors that influence movements and foraging behavior of this stock of bowhead whales.

**Speakers: Bering Sea and Aleutian Islands**  
*Ecosystem Perspectives*

**Shifting Baselines through a 5000 year History of the North Pacific / Bering Sea Marine Ecosystem**

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Sustainability, resource management, and the protection of endangered species on the north Pacific and southern Bering Sea suffer from the shifting baselines phenomena because they are based largely on recent trends. Marine ecologists and fisheries biologists have little knowledge as to whether spatial and temporal patterns of the last 50 years are products of local marine system dynamics, a result of ecosystem engineering by human harvesters, or global marine cycles spanning decades or millennia. The archaeological analysis of over 100,000 mammal and fish bones from archaeological sites in the western Gulf of Alaska and southern Bering Sea spanning 5000 years highlight major shifts in the abundance and distributions of keystone species. We find some species are likely adapted to human harvesting such that their behavioral ecology can be considered a product of human ecosystem engineering. Conversely, some of the most widely harvested species show no evidence of human impacts at all, yet are susceptible to minor variations in climate, marine productivity, and other hemispheric level phenomena. We further find that some of the most important commercial species of the last few decades were not present at certain times in the past. Finally, we show that both humans and climate have played key roles in the structure of the greater North Pacific ecosystem, and that a broad understanding of both top down and bottom up processes is critical to the long-term sustainability of the hemisphere's last great fishery.

**Speakers: Bering Sea and Aleutian Islands**  
*Ecosystem Perspectives*

**Climate to Fisheries: 40-year Hindcast of Vertically Integrated Model for the Eastern Bering Sea**

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One of the main efforts of the Bering Sea Integrated Ecosystem Research Program is to synthesize current knowledge of climate, oceanography, lower trophic levels and fish dynamics into a high resolution spatial model geared to hypotheses testing and forecasts under different climate scenarios. Hindcasts are usually performed to evaluate the reliability of the model exercise. Here, we present results of the fish portion FEAST (Forage-Euphausiid Abundance in Space and Time) which models 12 fish species linked to 5 zooplankton groups and 20 fisheries specified by sector, gear and target species. Species include walleye pollock, Pacific cod, arrowtooth flounder, salmon, capelin, herring, eulachon, sandlance and myctophids, squids, shrimp and epifauna; these have a two-way interaction with five groups from the NPZ module: small/large copepods, oceanic/shelf euphausiids and benthos. Temperature and advection estimates from the physical oceanography portion are used in the fish bioenergetics, movement and reproduction components. The hindcast is compared to general patterns obtained from historical time series, and the first 4 years (2007-2009) of field data collected as part of BSIERP. This presentation summarizes the model's performance, what processes it captures, what it does not, and the implications for forecasts and the use FEAST as the operating model for Management Strategy Evaluation in the eastern Bering Sea fisheries.

**Speakers: Bering Sea and Aleutian Islands**  
*Ecosystem Perspectives*

**Spatial Considerations for Analyses of Trophic Stability in Marine Ecosystems**

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Recent analyses have characterized the impacts of fishing exploitation and described shifts in marine community structure on the basis of trends in mean ecosystem trophic level. Both data source and spatial scale have important impacts on the results of such analyses. There are several mechanisms that might drive ecosystem structure, stability and dynamic shifts in marine systems, including fisheries extraction, climate, and inter-specific competition. At the community level, we examine whether populations are driven primarily by shifts in abundances of co-occurring competitors or by responses to environmental drivers. We develop an integrated assessment of the Bering Sea, Gulf of Alaska and Aleutian Islands ecosystems, comparing catch data, survey data and stock assessments to provide a more complete analysis of whether shifts in species abundance reflect changes in the ecosystem and at what scale. As an approach to evaluate ecosystem stability and resilience, we examine species succession and trends in relative species abundance within functional guilds. Specifically, we evaluate the relative impacts of environment and harvest on patterns of species replacement within groups of similar species. We evaluate evidence for compensatory dynamics, resource partitioning, and shifts in species distributions. We also examine the relative effects of various drivers of species abundance through multivariate autoregressive state-space models. These analyses are intended to determine whether individual populations within functional guilds are more variable than in aggregate and identify the level at which compensation is expressed in these systems. We also consider the extent to which species are interchangeable from an ecosystem and a market perspective.

**Speakers: Bering Sea and Aleutian Islands**  
*Ecosystem Perspectives*

**New Insights on the Northern Bering Sea Ecosystem from Early Seasonal Sampling in  
March 2008, 2009 and 2010**

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Early spring observations in the northern Bering Sea have been rare, but icebreaker deployments in March of 2008, 2009, and 2010 provide new data on the early season distribution of its emblematic fauna and flora, together with new insights on overall ecosystem function. The composite picture that emerges from these observations is of a biologically active system with strong atmospheric and hydrographic controls. These controls pre-determine nutrient and chlorophyll distributions and water column mixing through brine rejection. Sea ice algal inventories of chlorophyll are high and correspond to water masses with high nutrient content. Nutrient availability clearly modulates open water and sea ice productivity and the transmission of organic material to the shallow benthos following sea ice retreat. Early spring re-suspension of ammonium also occurs from some sediments leading to bottom water ammonium concentrations of  $>5 \mu\text{M}$ . Early spring is also an important foraging period for benthic-feeding Pacific walrus. Feeding patterns reflect benthic biomass and sea floor community structure. Sea ice dynamics in addition to benthic food availability also plays a role in the scale and distributions of other benthic-feeding apex predators such as spectacled eiders. Two alcid seabirds that feed throughout the water column on euphausiids, amphipods and small fish, the black guillemot and Kittlitz's murrelet, were among the few late winter avian residents observed to take advantage of open water in the polynyas south of Saint Lawrence Island. A wider range of marine bird species and higher bird abundance was observed near the edge of the ice pack.

**Speakers: Bering Sea and Aleutian Islands**  
*Humans*

**Definition of Multi-species Control rules for the Bering Sea Management Strategy Evaluation**

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There is a strong movement both nationally and internationally to implement ecosystem-based fisheries management, in particular to account for multi-species trophic interactions when estimating quotas and providing fisheries management advice. However, simultaneously maximizing biomass across a broad group of interacting species is not straightforward. Control rules for multi-species assessment models, including overfishing limits (OFL) and acceptable biological catch (ABC), are a key requirement for their implementation, but a standard definition or application does not exist. The management strategy evaluation project of BSIERP is developing models and tools to compare single-species and multi-species stock assessment methods under different management strategies and climate change scenarios. We hosted a two-day workshop consisting of stock assessment scientists, ecosystem modelers, and industry stakeholders with a key goal being the development of multi-species control rules. These multi-species control rules are being applied to: MSM, a predator-prey multi-species stock assessment model; and the AFSC Ecosystem model, a food web model similar to Ecopath with Ecosim (EwE). The definition of multi-species control rules was a key step in the ability to compare fisheries management using single-species and multi-species assessment models in a changing environment.

**Networks of Sustainability in North Aleutian Basin Communities**

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Subsistence and commodity exchange networks in the North Aleutian Basin reflect systems dominated by key nodes connecting large, loosely defined kin and marriage-based households. Research contracted with the U.S. Bureau of Ocean Energy Management (BOEM) to identify key characteristics of community resource, land, and sea use in four southern Bering Sea villages proximate to the proposed (and canceled) North Aleutian Basin offshore oil and gas development required the construction of new methods of network analysis structured by affinal and consanguineal relationships. We find that each community contains one over-arching network for each subsistence species that dominates a number of small family networks. These network nodes (primary providers) produce the majority of subsistence products that are transferred to other members of the community. We show that the loss of any one of these key nodes has dramatic structural impacts on the sustainability of exchange networks in this region, and thus, the community's ability to maintain a subsistence lifestyle. This research further demonstrates that traditional subsistence studies that identify species and quantities hunted and gathered by individuals in households, without reference to how these harvests support community and regional exchange networks, do not fully represent the critical importance of subsistence goods and other commodities in Alaskan villages.

**Speakers: Bering Sea and Aleutian Islands**  
*Humans*

**Critical Human Dimensions of Maritime Oil Spills**

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This presentation describes the results of a long-term, in-depth BOEM-funded ethnographic study of Alaska's second largest maritime oil spill: that of the Malaysian-flagged freighter, the Selendang Ayu. The spill began in December 2004 during storm force conditions in the south-central Bering Sea; the Natural Resource Damage Assessment (NRDA) process continues to date. Despite initial attempts by the U.S. Coast Guard to secure the freighter, it ran aground on a rocky reef near Skan Bay on Unalaska Island. Six lives were lost during a heroic rescue effort. The ship spilled its cargo of soybeans; 321,052 gallons of IFO 380; and 14,680 gallons of diesel fuel and other oils. Early response work was followed by a cleanup effort that lasted until June 2006. Certain shoreline segments could not be remediated. Given travel distances to and from Unalaska/Dutch Harbor, and the remote location of the grounding, response work was particularly challenging for government agencies and resulted in known expenditures of over \$100 million. The accident induced problems in the commercial fishing sectors and among Unalaska's subsistence practitioners. Although the state-sponsored subsistence foods testing program revealed no significant threat from polycyclic aromatic hydrocarbons (PAHs), certain residents continue to express uncertainty about the safety of foods from the affected area. A tribal claim for subsistence losses was rejected by the National Pollution Funds Center in 2009. The spill led to establishment of the Aleutian Islands Risk Assessment, which is currently functioning to improve regional spill response capacity, with lessons for planners and policy-makers elsewhere in the United States.

**Evaluating the Effectiveness of Rolling Hotspot Closures for Salmon Bycatch Reduction  
in the Bering Sea Pollock Fishery**

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Bycatch is commonly noted as a primary problem of fisheries management and has been a recurrent management concern in the North Pacific. Bycatch levels of chum and Chinook salmon rose substantially beginning early in the last decade, with chum bycatch peaking in 2005 and Chinook bycatch reaching a record high in 2007 before bycatch of both species declined. In the Bering Sea pollock fishery, Chinook and chum salmon bycatch reduction measures have consisted principally of area closures, although a Chinook salmon bycatch hard cap with individually bycatch allocations went into effect beginning 2011 which would close the fishery if the cap were reached.

Since the mid-1990s, area closures aimed at bycatch reduction have consisted of both large long-term Salmon Savings Area closures and short-term rolling hotspot (RHS) closures. Significant areas of the pollock fishing grounds have been closed at some point in all years between 1995 and 2011. Currently, the North Pacific Fisheries Management Council (NPFMC) is considering several measures to reduce chum bycatch, including evaluating means to improve industry-imposed RHS closures. In this paper, we quantify the reduction in bycatch following the implementation of actually RHS closures. Additionally, we simulate the impacts of dynamic bycatch closures in historical periods when closures were not in place and compare the relative effectiveness of different dynamic closure system characteristics. We also briefly discuss the hard cap and incentive plan agreements (IPAs) that were put in place in 2011 to reduce Chinook salmon bycatch.

**Speakers: Bering Sea and Aleutian Islands**  
*Climate and Oceanography*

**Four Decades of Climate-Biology Covariation in Alaska**

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Understanding the impacts of climate change in Alaskan marine ecosystems requires distinguishing the effects of global warming from the effects of natural climate variability and fishing. We tested for global warming effects across 37 Alaskan populations (1965-2007) while also accounting for the effects of other important forcing mechanisms (PDO, Victoria Pattern, Arctic Oscillation, ENSO, size of the commercial catch). Using non-parametric regression and a model selection approach, we found that mean global temperature was significantly related to variability in the first two principal components (PCs) of the biology time series. Global temperature explained 2-3 times more community variability than all of the other forcing mechanisms combined. Additionally, we found strong correlation between global temperature and Alaskan climate parameters, a result that is consistent with a mechanistic relationship between global warming and Alaskan ecosystem variability. Because increases in global temperature are highly linear, our analysis would likely find a correlation between global warming and any gradual community change, from whatever cause. Our correlative results therefore require confirmation by more mechanistic research. We provides hypotheses for such research by placing change in individual populations within a framework of community-level variability that is statistically associated with anthropogenic climate change. Of particular interest in this context is the decline since 1988/89 in the importance of PC1 from our analysis, which tracks community change traditionally associated with the 1970s PDO regime shift, and the simultaneous increase in importance of PC2, which tracks community change in the Bering Sea.

**Bering Strait Throughflow from a Global Ocean Model**

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The Bering Strait (BS) is the gateway between the Pacific and Arctic oceans, and exerts a critical influence on global climate and ecosystem processes. Observations exhibit large interannual variability in temperature, salinity and transport. Previous studies estimate long term mean transport to be 0.8Sv, but often with the caveat that this number does not include occasionally or seasonally present coastal currents, such as the Alaskan Coastal Current (ACC). Using a regional ocean configuration of a global circulation model (the Massachusetts Institute of Technology General Circulation Model; MITgcm), we extracted vertical sections (6 horizontal cells, 2-5 vertical layers) that correspond to existing mooring positions in the BS. Point to point comparison for temperature and salinity between the model and the moorings show that the model has the same seasonal cycle as observations. Calculations of the modelled long term mean velocity across a section including the ACC closely matches previously published data made at a single point (the A3 mooring) that does not include the ACC. By assuming that A3 is representative of the BS, as in previous studies, long term mean transport calculated by the global model is 0.8Sv. However, model calculations show that the mean velocity across the BS is influenced by the ACC, and A3 is not an ideal representation of flow through the BS. Using the model BS velocity, we refine estimates of long term mean BS transport to be 1.1Sv, suggesting that around 30% of BS transport is excluded by omitting the ACC.

**Speakers: Bering Sea and Aleutian Islands**  
*Climate and Oceanography*

**Black Swans in the Bering Sea: Physical and Biological Uncertainty**

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Black swans are improbable events that do not follow classic statistics. The name comes from a book, *The Black Swan* by N. Taleb. These ideas change how we interpret the science that we do. The meteorology and oceanography of the northern North Pacific appears to be governed by classic statistics (means and variance) due to the nature of storm tracks. For recent multi-year warm and cold events (1971-1976, 1978-1983, 2000-2005, 2007-2010) we cannot rule out that they are of a random nature: they are rare in the temperature record, they are dominated by North Pacific-wide sea level pressure events rather than local processes, and they are consistent with a red noise model of climate variability. Recent changes in the northern Bering and Chukchi Seas, however, are in the nature of frequent large surprises that include feedback processes: the loss of sea ice extent, warmer temperatures, and marine mammal impacts. They are part of an Arctic-wide "New-Normal." Biological systems often follow power-laws, where events occur more often than suggested by Gaussian probability distributions. Bering Sea pollock recruitment occurs spatially in multiple hot spots which increase in number in warm years, a fractal distribution. Thus, in the past and the future we can expect large climatic and biological excursions that can last for multiple years, but there is little regularity (oscillations) or predictability for their timing and duration.

**Speakers: Bering Sea and Aleutian Islands**  
*Lower Trophic Levels*

**Phytoplankton Biomass and Size Structure During Late Summer / Early Fall in the Eastern Bering Sea**

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The NOAA BASIS program (Bering Aleutian Salmon International Surveys) conducted fisheries oceanography surveys in the eastern Bering Sea, mid-August to late September, for three warm (2003-2005) followed by four colder (2006-2009) years. Spatial and interannual variations in total phytoplankton biomass and size structure (an indication of phytoplankton species) were determined from total and size-fractionated chlorophyll a (chl<sub>a</sub>) concentrations. Phytoplankton biomass and species composition determine the amount and quality of food available to zooplankton and higher trophics, and are thus critical to ecosystem function. Discrete water samples were used to estimate large size-fractions (>10 μm / total chl<sub>a</sub>) and calibrated CTD chl<sub>a</sub> fluorescence profiles used to estimate mean and integrated chl<sub>a</sub>. Results indicate that phytoplankton assemblages in the south Middle shelf were larger in 2003-2005 than in 2006-2009. Highest biomass occurred in the Outer shelf, near the Pribilof Islands and in south Inner shelf, and lowest biomass in the north Bering and SE Middle shelf, in regions of high stability. Larger phytoplankton assemblages were seen on the Inner shelf and near Pribilof I., and smaller phytoplankton on the SE Middle shelf (region of low total chl<sub>a</sub>) and Outer shelf (region of high total chl<sub>a</sub>). Water column stability and wind may influence interannual and spatial variations in phytoplankton biomass and size structure, with deep nutrient-rich waters mixed to the surface to fuel production of large assemblages during periods of high winds and low water column stability.

**Speakers: Bering Sea and Aleutian Islands**  
*Lower Trophic Levels*

**Predicting the Impacts of Changing Environmental Conditions on Lower Trophic Level  
Ecosystem Dynamics in the Bering Sea**

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Despite frequently being ice covered until March the continental shelf of the eastern Bering Sea is one of the world's most productive marine ecosystems, with its fisheries representing half of the marine harvest in United States waters. Large changes in lower trophic level ecosystem dynamics have been observed on inter-annual and inter-decadal time scales, although the mechanisms giving rise to these changes are not well understood. We present a lower trophic level ecosystem model for the Bering Sea that has been developed to explore relationship between climate, ocean conditions, productivity and flow of energy through the food web. The core of the ecosystem model is a Nutrient-Phytoplankton-Zooplankton model which has been coupled to an ice-biology module and to a benthic sub-model. This modeling effort is a fundamental element of an integrated program to develop a forecast system for predicting the effects of future climate change on the ecosystem of the Bering Sea. Validation techniques for the model using available field data will be discussed and model predictions of the influence of changing environmental conditions on lower trophic level ecosystem dynamics in the Bering Sea presented.

**Development of a Quantitative PCR Assay for Detection of Planktonic Red King Crab  
(*Paralithodes camtschaticus*) Larvae**

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We designed primers and a dual-labeled probe for use in a DNA-based quantitative polymerase chain reaction (qPCR) assay targeting the red king crab cytochrome oxidase I mtDNA for the detection of red king crab larvae in plankton samples. The assay technique allows identification of plankton samples containing crab larvae and provides an estimate of crab DNA present in a sample without visually sorting the plankton sample. The assay was tested on red king crab larvae and seeded plankton samples and allowed detection of 1/10,000th of a larva and one crab larva per 5 mls of sieved (large material removed) plankton. Larval crab distribution is temporally and spatially patchy, requiring extensive sampling efforts to locate and track larval dispersal. Large-scale plankton surveys are generally cost-prohibitive due to the effort required for collection and the time and taxonomic expertise required to sort and individually identify plankton via light microscopy. The qPCR assay can be used to screen plankton samples for red king crab larvae in a fraction of the time required for traditional microscopy-based methods. This offers obvious advantages for stock assessment methodologies for red king crab with a quick and reliable method to assess abundance of red king crab larvae as needed to improve the understanding of life history and population processes, including larval population dynamics. The Alaskan red king crab fishery, currently depressed, but once one of the most economically important single-species fisheries in the world, would benefit greatly from improved stock assessment capabilities.

**Speakers: Bering Sea and Aleutian Islands**  
*Fish and Fish Habitat*

**Interannual and Seasonal Variability in the Size-Fecundity Relationship for Red King Crab (*Paralithodes camtschaticus*), with Considerations of Maternal Size effects on Embryo and Larval Quality**

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Stock assessment of Alaskan red king crab, *Paralithodes camtschaticus*, can be improved by incorporating reproductive output, which requires an understanding of interannual and seasonal variability in fecundity and maternal size effects on fecundity and embryo and larval quality. We collected egg clutches from Bristol Bay, Alaska, in summer of 2007-2010 and autumn of 2007-2009 and estimated fecundity using dry weight methods. In 2009 and 2010, embryo quality based on dry weight, carbon and nitrogen content was assessed. In 2008, larval quality based on dry weight, carbon and nitrogen content, and time to 50% mortality under starvation conditions was assessed. Fecundity increased with female size up to 138 mm carapace length (CL), after which the slope decreased by 40%, suggesting senescence. Slight (maximum 5%) but statistically significant variations in fecundity were observed among years. Fecundity was consistently lower in fall than spring, suggesting brood loss, with a 6% decrease between seasons in females < 138 mm CL and 10% decrease in larger females. Among the measures of embryo quality, only nitrogen content significantly increased with maternal size. Carbon and nitrogen content were significantly higher for embryos in 2009, suggesting interannual differences in maternal investment. No effect of maternal size with larval quality was found, suggesting that differences in embryo nitrogen content may not equate to increased larval quality. When incorporating reproductive output in stock assessment, variation in the size-fecundity relationship should be incorporated, but variations in embryo and larval quality are small and therefore not critical for inclusion during assessment.

**Studying Giant Pacific Octopus in Alaska**

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NPRB Project 906 was conducted in support of new and extremely data-limited stock assessments for octopus in the Bering Sea and Gulf of Alaska. The objectives were to gather basic life-history data on the giant Pacific octopus *Enteroctopus dofleini* in Alaska, and to test two field methods for octopus-specific studies. Dissection of octopus specimens provided a direct method for assessing reproductive stage, and estimates of parameters such as size at maturity and average fecundity. Dissection data suggested that there is not a single synchronous reproductive season for *E. dofleini* in Alaska. Mature adults were present throughout the year, but there was an increase in the frequency of adults with high GSI in the fall months. Both field methods showed excellent feasibility for studying octopus. Longlined habitat pots caught octopus in a wide range of sizes, including mature males and females. Several materials were tested; habitat pots made from plywood and scrap tires had the highest catch rates. Catch rates varied dramatically between seasons, from <10% to nearly 50% occupancy. The 44 ft charter vessel was able to fish 200-300 pots/day with minimal deck crew. Tagging of octopus with visible implant elastomer (VIE) tags proved highly feasible, with short-term recapture rates up to 15% and no evidence of tissue infection or loss of visibility of tags. A total of 410 octopus were tagged and 35 recaptured during brief field studies in the fall of 2009 and spring 2010. Octopus tagging studies in the Bering Sea are continuing under NPRB funding.

**Speakers: Bering Sea and Aleutian Islands**  
*Fish and Fish Habitat*

**Applying Ocean Observations to Support Fishery Management During Climate Change**

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Management decisions in the coastal salmon fisheries depend on the timing of arrival of the salmon migrations (runs) in harvest areas in, or near, river mouths. Annual salmon run timing changes sharply in apparent concert with environmental factors, such as water and air temperatures, that could change acutely in high latitudes with global climate change. Mechanisms of environmental control of timing are not well established, however our hypothesis is that navigation and physiological readiness to enter freshwater are controlled by factors related to marine water column stability near the river's mouth. Using historic data, linear models defining salmon timing as functions of ocean variables were developed and applied prospectively to successfully forecast timing of Chinook salmon in the lower Yukon River prior to the start of migrations in 2010 and 2011. Early Spring ice cover, and sea surface and air temperatures are closely related to salmon entry timing, as measured by the Lower Yukon Test Fishery. Since 1961 high percent ice cover and low temperatures in early Spring have nearly always been followed by late or average runs, however timing of runs following early Springs with low ice cover and warm temperatures varied from very early to late. In 2010 and 2011 dates of each run's percentiles were forecast with errors of zero to three days, which are small compared to the twenty-day range of the fiftieth percentile over the past 51 years. Decreasing ice cover would decrease the predictability of timing, making fishery management more challenging.

**Small Scale Abundance and Movement of Atka mackerel 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. This talk will present a study that assesses the small-scale abundance, movement, and local exploitation rates of Atka mackerel, the dominant prey of sea lions in the Aleutian Islands, in relation to management boundaries such as Trawl Exclusion Zones. In 2011 we tagged approximately 27,000 fish in three areas of local Atka mackerel abundance in the Aleutian Islands. During our tag recovery cruise in August 2011 110 tagged Atka mackerel were recovered. In addition, we used an underwater camera for the first time on this platform to assess Atka mackerel habitat and spawning activities as well as explore the possibility of non extractive survey methodologies. We also used recovery tows to estimate an index of abundance for other Steller sea lion prey species. This talk will give the preliminary results of the first year of field efforts from this study.

**Speakers: Bering Sea and Aleutian Islands**  
*Seabirds*

**Seasonal Spatial Relationships Between Seabirds and their Prey –  
a Moveable Feast in the Southeastern Bering Sea**

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Seabirds are central place foragers while breeding, and presumably disperse to find prey and replenish energy reserves prior to winter, but there are little data from the post-breeding season. We used vessel-based surveys to examine seasonal changes in predator-prey spatial relationships in the southeastern Bering Sea. We compared seabird (birds/km<sup>2</sup>) and prey (fish/nmi<sup>2</sup>) densities during summer (June-July) and fall (late August-October) of 2008-2010. Data were collected from 32,000 km of transects within a 400,000 km<sup>2</sup> study area and summarized over a 37x37 km grid. Prey included age-0 and age-1 walleye pollock *Theragra chalcogramma* and Pacific cod *Gadus macrocephalus*, other forage fishes, and euphausiids. Different prey types were sampled in summer and fall, making inter-seasonal comparisons difficult to interpret, but both seabirds and prey showed species-specific spatial patterns that were often consistent across years. In summer, most birds that breed in Alaska were concentrated around colonies or along the shelf break, but dispersed to the mid and inner shelf in the fall; this coincided with the fall distribution of capelin *Mallotus villosus* and juvenile herring *Clupea pallasii* in the north and inner shelf, and juvenile cod and pollock in the south. Shearwaters *Puffinus* spp do not breed in Alaska, and in summer they aggregated along the Alaska Peninsula where euphausiid abundance was high, but they dispersed northward in the fall. Results suggest that while the outer shelf is critical in summer, forage species in the mid and inner shelf are important pre-winter resources for seabirds in the southern Bering Sea.

**Speakers: Bering Sea and Aleutian Islands**  
*Seabirds*

**Inter-annual Variability in Foraging Behavior and Diet of Black-Legged Kittiwakes Nesting at the Pribilof Islands: the Role of Mesoscale Eddies**

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We investigated the foraging distribution of nesting black-legged kittiwakes, a surface feeding piscivore, and its relation to oceanographic features, prey fields, and chick survival during three cold years (2008-2010) in the southeastern Bering Sea. We simultaneously tracked the foraging trips of adult kittiwakes during chick-rearing at two Pribilof Island colonies (St. Paul and St. George). Kittiwakes from the two colonies used different foraging areas in all years, but there was surprisingly little overlap with the shelf break. Remote sensing, tracking, and diet data all suggested that foraging kittiwakes targeted myctophids as prey in association with mesoscale basin eddies (cyclonic and anticyclonic). These eddies persisted throughout the season and varied in intensity among years. Kittiwakes from both Pribilof colonies focused daytime foraging over the shelf; however, shelf-based forage fishes (e.g., juvenile pollock and sandlance) were only prevalent in the diet of St. Paul kittiwakes. Overnight foraging trips were long-distance, over the basin, and targeted myctophids, regardless of colony of origin; however, in 2009 St. Paul kittiwakes foraged primarily over the shelf even at night. In 2009, kittiwake fledging success was lower at the St. Paul colony, suggesting the quantity and quality of available food was limiting. In 2008 and 2010, when St. Paul kittiwakes undertook overnight foraging trips to the basin and provisioned their young with myctophids, fledging success was higher. Overall, in cold years with low abundance of juvenile pollock over the continental shelf, the predictability of myctophids, whose availability over the basin may be enhanced by persistent eddy features, was critical for the breeding performance of Pribilof kittiwakes.

**Speakers: Bering Sea and Aleutian Islands**  
*Seabirds*

**Integrative Approaches to Marine Ecology Utilizing Fatty Acids, Stable Isotopes, and Spectroscopy**

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Planktivorous auklets and juvenile salmon occupy trophic niches near the base of marine food webs. These guilds integrate information about lower trophic levels that is useful for understanding ecological processes and change. We used fatty acid analysis (FA), stable isotope analysis (SI), and Raman spectroscopy to analyze adipose tissue, muscle tissue, feathers and other tissues. We tested the utility of these methods at temporal scales ranging from seasonal to interdecadal, and at several geographic scales. FA analyses discriminated juvenile salmon in interspecific and interannual comparisons, as well as intraspecific differences related to the ecoregions where the fish were caught. SI analyses discriminated some of the same patterns, providing independent confirmation of FA results. SI also provided additional insights into causes of variability. For example, both analyses discriminated juvenile chum according to location, while isotope signatures of enriched oceanic production were evident as a key factor. RAMAN spectroscopy revealed a relationship between abundances of total carotenoids and specific FA biomarkers in salmon, linking food quality to indices of health. Temporal and geographic differences were also evident in the FA and SI composition of auklets. Auklets were discriminated between oceanic systems (Bering Sea vs. Gulf of Alaska) and also between colonies within the Bering Sea (Pribilof, St. Lawrence, Little Diomedes Is.), demonstrating regional differences in food web structure. On temporal scales, auklet FA and SI revealed seasonal patterns that indicated reliance on local versus advected production, and interdecadal patterns that suggested long term changes at the base of the food web.

**Speakers: Bering Sea and Aleutian Islands**  
*Mammals*

**Boundary Bound: Fur Seal Foraging Hotspots are Related to Thermoclines and Fine-scale Fronts**

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Northern fur seal populations in the eastern Bering Sea are declining at St. Paul Island and increasing at Bogoslof Island. The population differences may be related to foraging trip duration, but the cause of such trip differences are unidentified. We hypothesized that fur seals on St Paul were forced to travel further to reach adequate foraging grounds, and that elevated prey concentrations were created by dynamic oceanographic features. We tested this by identifying foraging hotspots with first-passage time (FPT) analysis on tracks from 87 females instrumented with bio-logging tags during July - September, 2009. We found no overlap in foraging areas between islands, but a difference in the duration of foraging trips: St. Paul trips were twice as long (7.9 d) and covered 3-times the distance (600 km) compared to trips from Bogoslof. We compared FPTs with oceanographic covariates to demonstrate that fur seal foraging hotspots were linked to thermocline depth and occurred near fine-scale surface fronts. Benthic divers from St. Paul focused their effort in areas with deeper thermoclines while epipelagic foragers tended to use waters with shallower thermoclines. Epipelagic divers foraging off-shelf also hunted intensely along fine-scale surface fronts. Strong fronts enveloped Bogoslof but were <100 km from St. Paul. We propose that the relative distribution and accessibility of prey-concentrating oceanographic features accounted for the differences we observed in foraging patterns between colonies, and that these differences may ultimately explain the divergent population trends of the two fur seal populations.

**Speakers: Bering Sea and Aleutian Islands**  
*Mammals*

***Coxiella burnetii* in Northern Fur Seal (*Callorhinus ursinus*) placentas from St. Paul Island, Alaska**

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The decline of northern fur seal (NFS, *Callorhinus ursinus*) pups on St. Paul Island, Alaska, has led to multidisciplinary research including investigation into issues of reproductive health and success. During the 2010 NFS pupping season, placentas were collected from Reef rookery on St. Paul Island, Alaska, examined histologically and tested for *C. burnetii* using PCR. Of 146 placentas examined, gram negative, intratrophoblastic bacteria that were positive for *C. burnetii* on immunohistochemistry (IHC) were observed in 5 (3%) placentas. Placental infection was usually devoid of associated inflammation or significant ancillary pathology. One hundred nine (75%) of the placentas were positive for *C. burnetii* on PCR. In attempt to determine the significance of infection within individual placentas, IHC markers of apoptosis (cleaved caspase-3 and the (TDT)-mediated dUTP-digoxigenin nick end labeling (TUNEL)) were compared between placentas infected with histologically identifiable organism, PCR positive placentas without organism seen on H&E and tissues negative on IHC and by H&E. There was a statistically significant difference in the frequency of apoptotic cells between all three infection groups with significantly more apoptosis identified in the uninfected placentas. This finding suggests that the survival mechanism of *C. burnetii* in host macrophages to reduce apoptosis may also be utilized in trophoblasts; the significance of decreased trophoblastic apoptosis for the fetus requires further investigation. *C. burnetii* is globally distributed and persists for long periods in the environment providing ample opportunity for exposure of many species. The significance of this finding for the declining fur seal population, potential human exposure and infection, and impact on other sympatric marine mammal or terrestrial species is unclear; further investigation into the epidemiology of *Coxiella* in the marine ecosystem is warranted.

**Speakers: Bering Sea and Aleutian Islands**  
*Mammals*

**Freshwater Harbor Seals of Lake Iliamna, Alaska Seasonal Haulout and Pupping Patterns  
with Possible Covariates Influences**

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Lake Iliamna is home to a unique colony (~200+) of freshwater harbor seals. NOAA's National Marine Mammal Laboratory, along with the University of Alaska-Anchorage and our native partners from the Bristol Bay Native Association and the Newhalen Tribal Council have combined resources to census these seals multiple times each year. In addition to gathering baseline information on seasonal shifts in abundance and distribution, a companion study was initiated which documents subsistence use patterns and local traditional knowledge (LTK) from communities that harvest seals, by interviewing village elders and hunters. We documented pupping (N=63 in 2010; N=43 in 2011) for the first time in the lake, which takes place in July rather than the usual mid-May to mid-June as seen elsewhere in the state. Aerial surveys in early April, when the lake is completely frozen-over, revealed the presence of seals (N=11 in 2010; N=73 in 2011) along pressure cracks in the ice and in pools which form in some shallow water areas. Seals responded differently than expected to covariates influencing haulout behavior such as time of day and lake water height. Seasonal differences in haulout numbers suggest some seals may not over-winter, however there are no known accounts of immigration or emigration despite access to Bristol Bay via the Kvichak River (120 km in length). Three genetic samples were collected during the 2011 subsistence hunt which should help to determine if this group of seals is different from the Bristol Bay stock of harbor seals, or is possibly a new sub-species.

**Does the Winter Range of Bowhead Whales Overlap Commercial Fisheries in the Bering Sea?**

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How often bowhead whales (*Balaena mysticetus*) become entangled in commercial fishing gear is unknown, although rope scars are identified on approximately 10% of harvested whales and a dead whale wrapped in "pot" gear, apparently causing its death, was found in July 2010. Rope scars are believed to result from entanglement in pot gear set in the Bering Sea; however, the relative positions of bowhead whales and the pot fishery was unknown until recent satellite tagging studies. In the winters of 2008-09 and 2009-10, the distribution of 20 tagged bowhead whales overlapped the locations of pot gear set for Pacific cod (*Gadus macrocephalus*) and blue king crab (*Paralithodes platypus*), yet the fisheries concluded before whales migrated into the overlap area. The snow crab (*Chionoecetes opilio*) fishery extends from January to April and provides the greatest risk for bowhead whales to encounter active pot gear. However, whales generally remained in areas with >90% sea ice concentration, which is too concentrated for crab boats. Although the distribution of pot gear in Russian waters is unknown, Russian fisheries are equally limited by sea ice. Hence, bowhead whales generally frequent waters too ice-choked for commercial fishing boats in winter and "ghost" gear (i.e., lost fishing gear) may be the main source of entanglement. Because this stock of whales is increasing, it is unlikely that fishery induced mortality limits the population. However, entanglement rates may increase if the location of the pot fishery shifts with changing ice conditions.

**Speakers: Gulf of Alaska**  
*Ecosystem Perspectives*

**Long-term Monitoring of Marine Conditions and Exxon Valdez Oil Spill-Injured Resources and Services**

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In the two decades following the Exxon Valdez oil spill (EVOS), and after extensive restoration, research and monitoring efforts, it has been recognized that full recovery from the spill will take decades and requires long-term monitoring of both the injured resources and factors other than residual oil that may continue to inhibit recovery or adversely impact resources that have recovered. Monitoring information is valuable for assessing recovery of injured species, managing those resources and the services they provide, and informing the communities who depend on the resources. In addition, long-term, consistent, scientific data is critical 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 spill. An integrated, five-year monitoring program, the start of an expected 20-year effort, has recently been initiated in the spill-affected area of the Gulf of Alaska with funding from the EVOS Trustee Council. This program will provide information on environmental drivers, pelagic and benthic components of the marine ecosystem and lingering oil impacts, along with coordinated data management and delivery services. The program will also include interdisciplinary syntheses of historical and ongoing monitoring data to address remaining questions about the recovery of injured resources and impacts of ecosystem change.

**Speakers: Gulf of Alaska**  
*Ecosystem Perspectives*

**Multispecies Age-structured Assessment in the Gulf of Alaska: Predation,  
Parameter Precision and Variance, and Implications for Fisheries Management**

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A multispecies age-structured assessment model (MSASA) for the Gulf of Alaska (GOA) is examined. Age-specific predation mortality is modeled as a flexible function of predator and prey abundances, fitted to stomach-content data. Modeled species include arrowtooth flounder (*Atheresthes stomias*), Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), Pacific halibut (*Hippoglossus stenolepis*) and Steller sea lion (*Eumatopias jubatus*). Estimated trophic structures and predation links show significant changes relative to the inclusion of higher trophic level predators. Survey selectivity and catchability are confounded with natural mortality in their relationship to determining cohort structure; including predation mortality in stock assessments can potentially reduce this confounding, resulting in improved model fits to catch data and survey indices. Simulation exercises show that model performance degrades more due to model misspecification and data scarcity than assumptions regarding data weighting and variance. The model structure is able to track complex population dynamics using a relatively simple predation framework, but variability in parameter estimates makes clear the need for improved stomach data. Explicitly modeling age-specific predation allows detailed assessment of the cascading effects of commercial fisheries removals, improving the robustness of harvest control rules and facilitating the practical implementation of ecosystem-based fisheries management.

**Speakers: Gulf of Alaska**  
*Ecosystem Perspectives*

**Quantifying Phthalates in Alaska Marine Organisms**

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The plastic debris in the North Pacific Gyre also known as The Garbage Patch has seen enough of its victims. It has been estimated that millions of seabirds and thousands of marine mammals die each year because they entangle themselves in the debris or ingest it. Aside from entanglement and ingestion, the harmful threat of plastic is the potential leaching of their toxic additives such as bisphenol A, phthalates, styrene, vinyl chloride and flame retardants in the marine environment. Uptake of these compounds by adsorption or absorption through the skin or binding to proteins and lipids poses a hazard to marine organisms throughout all trophic levels. Little work has been done to determine the level of toxic plastic additives in the tissue and organs of these organisms. The focus of this research was to determine the levels of six common phthalates in different trophic levels found in the coastal regions of Alaska. Tissues from marine birds, Alaskan salmon, halibut and clams were analysed using liquid chromatography tandem mass spectrometry (LC MS/MS) with atmospheric pressure photo-ionization (APPI) to detect trace levels of six common phthalates. Significant levels of two of the most common phthalates were seen in the clam and bird tissue samples. These compounds are toxic to higher trophic levels and have already been banned in most of the European Nations and the United States.

**Can Rising Variance Predict Sudden Shifts in Populations and Ecosystems?**  
**A Test Using Alaskan Crustacean Data**

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Marine populations and ecosystems may respond to external forcing with abrupt reorganizations that are devastating to fishing communities. There is currently no method allowing early warning of these reorganization events. However, recent developments in ecosystem modeling suggest a novel approach to this problem: using the variance of key parameters to monitor ecosystem status, rather than the mean. We used Alaskan crustacean populations as a model system for testing this "variance tracking" method, conducting retrospective analysis to test for increases in the variance of fishery parameters prior to historical stock collapses. Our results generally supported the variance tracking approach. Six of twelve collapsing fisheries showed significant increases in the spatial variability of catch size prior to collapse, and a random-effects model found a significant effect across all collapsing fisheries. We could detect the signal of increasing variability up to four years prior to fishery collapse, suggesting that rising variance might give managers enough warning to avoid collapse. Furthermore, we found a significantly greater trend in variability for collapsing fisheries compared with non-collapsing fisheries ( $n = 2$ ). However, a key prediction of ecosystem models, that increased variance should be found only around the collapse point, was not supported, as we found that increased variance was a persistent feature of post-collapse fisheries. This result suggests fishing as the cause of the increased variance that we observed, rather than the alternate stable state dynamics that are the theoretical basis of the variance tracking approach.

**Speakers: Gulf of Alaska**  
*Humans*

**The Gulf of Alaska Ecosystem Workshop – Extending a Model for Transforming Ecosystem Science into Educational Resources**

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The North Pacific Research Board (NPRB) has launched landmark integrated ecosystem projects for the Bering Sea and Gulf of Alaska, and is exploring an Arctic program. To share the outcomes of these studies, NPRB has partnered with COSEE-Alaska, AOOS, ARCUS, and MBARI to bring together teachers, informal educators, and scientists for professional development workshops. The Bering Sea Ecosystem Workshop took place in October, 2010, and in July, 2011, a Gulf of Alaska Workshop was held in conjunction with an MBARI EARTH (Education and Research: Testing Hypotheses) Workshop.

Using ecosystem study hypotheses as a guide, and EARTH's focus on the use of data in the classroom, educators and researchers presented and learned from each other in Anchorage and at the UAF/NOAA Kasitsna Bay Laboratory. Teachers and informal educators refined existing lessons and created new educational materials based on researchers' presentations. The scientists also gained insights into how to communicate with educators and students.

New resources generated during the workshop can be found on the EARTH website, [www.mbari.org/earth](http://www.mbari.org/earth). Resources include presentations, lesson plans, and related educational materials and links, providing educators with Gulf of Alaska learning materials similar to the ones generated by the Bering Sea Ecosystem Workshop hosted through ARCUS's PolarTREC Learning Resources database at <http://www.polar trec.org/collections/bering-sea-ecosystem>.

Through these interactive workshops, researchers helped create resources that will bring current marine research in Alaska into the classrooms throughout the country in an accessible and stimulating manner.

A third workshop for the Arctic Ocean Ecosystem is being planned in Barrow in May, 2012.

**Speakers: Gulf of Alaska**  
*Humans*

**Using Blue Mussels as an Indicator Species for Testing  
Domoic Acid Toxicity in Subsistence Bivalve Harvest**

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Alaska has harmful algal bloom (HABs) problems affecting human health from personally harvested bivalve shellfish. The best documented HAB is the dinoflagellates *Alexandrium* sp. causing Paralytic Shellfish Poisoning (PSP). With over 175 outbreaks documented since 1972, PSP regularly causes illness and death. One emerging toxin found in low concentrations is domoic acid (DA) produced by several diatom species in the genus *Pseudo-nitzschia*. Infrequently tested shellfish has not revealed a distribution pattern of the toxic algae or the toxin concentrations in Alaska shellfish. This project developed a shellfish testing program for DA at multiple geographically disbursed sites, from southeast Alaska to Unalaska. Using trained citizen monitors, weekly sampling of mussels from ten sites occurred from July 1 through September 30, 2009. The samples were shipped to the Mercury Science Inc. for testing using a rapid enzyme-linked immunosorbent assay developed by NOAA. Samples were also sent to the Alaska Department of Environmental Conservation (DEC) for analyzes. Communities not included in the regular sampling program submitted samples for testing. Outreach on HABs, and DA was a major component of the project. Program participants, interested citizens, government agencies, academic institutions, environmental organizations received test results, and were posted on the Alaska Ocean Observing System (AOOS) and National Status and Trends websites. The results indicate there was little to no high DA concentrations in Alaska waters in 2009. We make recommendations for continuing a DA monitoring program in Alaska to protect human health, the fish and shellfish industries and build predictive models.

**Vulnerability of Alaska's Coastal Communities to Climate Change in the Kenai Peninsula**

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The people and cultures of Alaska are in transition, coping with change on a day-to-day basis, but with varying degrees of success. Historically, Alaskans have been extremely successful in responding to changing environments; however, the rapid and unprecedented nature of today's environmental and societal challenges create special needs and many Alaskans are faced with taking short-term mitigative actions at the expense of long-term goals such as health and sustainability. Working specifically in the context of commercial fisheries in Cook Inlet, this project investigate how people are responding to complex environmental, societal, and economic challenges, with the goal of identifying the circumstances that support or limit effective responses to change (i.e., adaptive capacity). Beginning with a "rapid vulnerability assessment" we are using a community-based participatory approach to understand the resources on which people need in order to successfully respond to changes in fisheries. We situate this approach is in contrast with the majority of vulnerability and adaptation work, which tends to presuppose the importance and relative weight of certain kinds of capital towards solving problems. We also discuss how this work on the human dimensions has explicit linkages to understanding and managing the marine environment and resources.

**Speakers: Gulf of Alaska**  
*Humans*

**Alternative Catch Monitoring of Alaskan Groundfish**

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Sampling catch onboard trawl catcher vessels is arguably the most difficult sampling situation currently faced by observers. This difficulty contributes to increase the variance of observer-derived estimates of catch and discard. Considering the limited amount of bycatch quota available to fishers, negative perceptions regarding the accuracy of observer data result. Alternative groundfish observer sampling methods were employed at-sea to disregard the retained portion of the catch (thereby increasing the observer's sampling fraction) and dockside to include species composition sampling from within the delivery (thereby addressing species identification concerns). Side-by-side sampling (altered vs. standard) was conducted at-sea and resulting catch estimates and variance properties were compared. Thirteen trips, each consisting of between 2 and 15 hauls (100 total), were sampled aboard eight vessels participating in three fisheries. Vessels delivered to four Kodiak processing plants. Alternative at-sea methods were found to be practical to implement, but required greater participation and cooperation from crew than standard methods. The utility of having two observers to monitor the delivered catch was quickly appreciated; one person was able to determine / verify the species composition of catch sorted above deck, while the other observer could simultaneously monitor/sample the unsorted catch from tanks located below-deck as it was pumped into the factory. Unbiased estimates appear to result from data collected using either method. Additional analyses, including an evaluation of the utility of each method will be presented.

**Speakers: Gulf of Alaska**  
*Climate and Oceanography*

**Advection of SST Anomalies along the North Pacific Polar Front and their Impact on the Gulf of Alaska, Aleutians, and Bering Sea Ecosystems**

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Advection of SST anomalies along the North Pacific Polar Front (NPPF) in 1930-2010 was studied from Hadley 1-degree climatology. The Polar Front Current associated with the NPPF acts as a conduit of oceanic anomalies originating in the NW Pacific. These anomalies propagate eastward along the NPPF into the Gulf of Alaska (GOA) where the NPPF retroflects and extends westward along the shelf break to the Aleutians and into the Bering Sea. Thus, the Polar Front Current connects ecosystems of the West and East Subarctic Gyres, Aleutians, and Bering Sea. Sporadic breakdowns of the along-front connectivity transpire as concurrent anomalies of opposite signs in the Western and Eastern Pacific Subarctic. The Polar Front Current carries relatively warm waters into the GOA and toward the Aleutians; therefore intensification (relaxation) of the Polar Front Current results in warming (cooling) of the high-latitude Northeast Pacific. Intensity of along-front advection varies on seasonal, interannual, and decadal scales. The unique succession of annual advective events in 1956-1966 was followed by a 20-year relaxation epoch, except for the 1971-1972 cold anomaly that traveled around the GOA and along the Aleutians. In 1986-1987, a major cold anomaly propagated into the GOA. The eastward advection episodes in 1990-1991 (warm and cold) and 1994 (warm) were followed by a major propagation event in 1996-1997 that culminated in an exceptionally strong warm event in the GOA in 1997, when SST anomaly south of Kodiak exceeded  $+2.5^{\circ}\text{C}$ . The large warm anomalies in the GOA in 2004-2005 were likely of local origin.

**Speakers: Gulf of Alaska**  
*Climate and Oceanography*

**Characteristics of "Gap Winds" in the Gulf of Alaska and their effects on regional oceanography**

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The Gulf of Alaska is surrounded by steep coastal mountain ranges. Pressure gradients across the mountains can result in strong "gap winds", low-level wind jets flowing out of gaps in the mountains. Gap wind events associated with Cross Sound, Yakutat Bay, and Iliamna Lake occur most frequently during the winter months. High resolution daily scatterometer wind data are used to identify and characterize gap wind events. In the eastern Gulf of Alaska (Cross Sound), the frequency of events is significantly correlated with the Multivariate Enso Index (MEI), suggesting that gap wind events occur more frequently in El Nino winters. Alternatively, in the western Gulf of Alaska, the frequency of events is not significantly correlated with the MEI but is correlated with the Pacific/North American (PNA) Pattern. Gap wind events can influence local oceanography and ecosystems through enhanced mixing, cross-shelf transport, eddy formation, small-scale horizontal and vertical circulations, and atmospheric dust transport/deposition. The Regional Ocean Modeling System (ROMS) Coastal Gulf of Alaska model will be used to examine the influence of gap winds on the regional ocean.

**Bathymetric Effects on the Circulation of Cross Sound, Alaska**

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Cross Sound, Alaska is a carved crossing of several fjord embayments set in southeast Alaska's Alexander Archipelago. Between May and August 2010, ten moorings were deployed at the entrances to Cross Sound and at key internal locations within the Sound. Instruments on each mooring measured current velocity, temperature, and salinity and data were analyzed for tidal harmonics and low-pass filtered to determine the non-tidal circulation of the Sound. The tidal range in this region is very large (>4 m), causing high current speeds (peak speed measured at 258 cm s<sup>-1</sup>). Due to the many constrictions and the rugged topography, the flow predominantly follows the bathymetry throughout the Sound across Glacier Bay and into Icy Strait; however, the shallow terminal moraine extending outside of Glacier Bay acts as a mixing zone and prevents the direct exchange of deep water between Icy Strait and Cross Sound. In most areas, the high speeds following the bathymetry determine a majority of the net transport as strong ebbs and floods are diverted into complex flow patterns. Even though some areas are relatively deep (>300 m), these conditions still generate large frictional forces causing high frequency shallow water and low frequency fortnightly tidal influences. This data set serves as a baseline for this area, which is experiencing rapid climatic changes due to glacial melt and isostatic rebound. This study combined with other regional studies elucidates the interactions between the physical and ecological processes within the archipelago and the exchange with the Gulf of Alaska.

**Speakers: Gulf of Alaska**  
*Lower Trophic Levels*

**Spatio-Temporal Analysis of Chlorophyll-a Concentrations in the Coastal Gulf of Alaska, 1998-2010**

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We examined spatio-temporal variations in surface chlorophyll-a concentrations of coastal Gulf of Alaska (GOA; 165-130°W, 50-62°N) waters from 1998-2010 using cloud-free reconstructions of 8-day and monthly SeaWiFS composites. The dominant EOF mode (~20% of total variation explained) represents the progression of the annual spring bloom, which usually begins earlier in the eastern GOA (<145°W), near-coastal waters, and Shumagin Islands. The second EOF mode (~14%) shows a strong, out-of-phase pattern inshore and offshore of the 1000m isobath west of 145°W and is correlated with periods of predominant upwelling or downwelling, whereas the pattern in the eastern GOA is coherent between inshore and offshore regions. There was a negative correlation between mean annual surface temperature and chlorophyll-a anomalies. Preliminary models suggest that a substantial portion of the variation in the timing, magnitude, and duration of the spring bloom in the east can be explained by the surface warming timing and early-spring freshwater discharge, whereas seasonal upwelling and downwelling explains more of the total variation in the west. We also explore correlations among bloom characteristics, zooplankton abundance, and survival of groundfish species.

**Identifying the Organisms Responsible For Causing Paralytic Shellfish Poisoning in Alaska**

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Paralytic Shellfish Poisoning (PSP) is a chronic health problem in Alaska. This illness results from the consumption of molluscan shellfish or crabs which have accumulated neurotoxins (saxitoxins) produced by harmful microalgae in the genus *Alexandrium*. Symptoms include numbness or tingling of the face, arms, and legs, headache, dizziness, nausea, and lack of muscular coordination. In severe cases muscle paralysis and respiratory failure may lead to death as occurred in SE Alaska last year. Standard saxitoxin detection methods are expensive and hard to perform in near real-time. As a result coastal regions in Alaska are not routinely monitored and are permanently closed to shellfish harvesting. To augment toxin testing, regulators in the northeast US and in Europe have developed monitoring methods based on cell counts and molecular assays which can predict when PSP events will occur. Developing a similar monitoring system for Alaska is not possible because the identity of the toxic *Alexandrium* species present in coastal waters is unknown. This project focused on identifying the toxic *Alexandrium* species are present in Alaska and on developing rapid species-specific molecular assays which can be used as a basis for a cell based PSP monitoring program. Our data indicate that two toxic species, *Alexandrium fundyense* and *A. ostenfeldii* are widely distributed along the southern Alaskan coast and are the species which dominated the toxic bloom in SE Alaska last summer. Details of the quantitative molecular assays used to detect these species and the relative toxicity of various isolates will be presented.

**Speakers: Gulf of Alaska**  
*Lower Trophic Levels*

**Sediment Organization in the Heterogeneous, Coarse-Grained Beaches of Western Prince William Sound:  
Long-Term Effects of Post-Oil Spill Beach Washing**

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Intense high-pressure washing of many beaches of western Prince William Sound (PWS) following the 1989 EXXON VALDEZ oil spill resulted in substantial reworking that possibly disrupted clast organization on these generally coarse-grained (granule to boulder) beaches. Field studies conducted at 38 oiled-and-washed (treated) and oiled-but-unwashed (untreated) beaches throughout PWS in June 2010, included general morphological characterizations, clast counts, grain-size analysis, shallow trenching, and photogrammetric analyses. The latter provided for the formulation of millimeter resolution digital elevation models (DEMs) of multiple ~1 m<sup>2</sup> study plots at each study site. These DEMs were quantitatively analyzed in concert with complementary grain-size data to calculate organization (armoring) metrics that reflect the interlocking and orientation of clasts. These metrics were used to compare sediment organization across washed and unwashed sites representing a wide range of exposure.

This study presents a first-of-its-kind approach to three-dimensional, high-resolution analysis and quantification of coarse-clast organization on gravel beaches. Our preliminary results suggest a negative correlation between beach washing and clast organization; that is, washed sites generally displayed a lower degree of organization, likely resulting from the severe disturbance undergone by the sediment during the washing process. This preliminary finding corroborates ecological evidence and suggests that lagging recovery in hard-shell clam abundance and diversity at washed sites in PWS is a consequence of disrupted organization of the coarse-grained sediments. This study provides a new approach to quantifying organization of coarser clasts in diverse settings and has wide-ranging implications for the use of high-pressure, washing techniques in cleaning oiled beaches.

**Speakers: Gulf of Alaska**  
*Fish and Fish Habitat*

**Completion of 30,000 Kilometers of ShoreZone Coastal Habitat Mapping in Southeast Alaska**

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The Southeast Alaska shoreline represents about 40% of the Alaska shoreline, and ShoreZone coastal habitat mapping has recently been completed for the entire 30,000 km of Southeast. Aerial surveys were flown during the lowest tides of the year to collect low-tide aerial imagery; video and photo imagery (>1 million video captures and >178,000 georeferenced photos) is all web-posted to allow open access. The interpretation of the imagery includes shoreline substrate, morphology and observed biota that are all systematically mapped in a searchable, georeferenced database. Some of the biotic resources that are mapped are closely associated with essential fish habitat including saltmarsh (~24% of the shoreline), understory kelps (~31%), eelgrass beds (~10%) and canopy kelps (~17%). Mapping shows that one or more of these resources occur along ~83% of the shoreline in Southeast. Over 7,000 shore units were mapped as estuaries, representing more than 3,000 km of shoreline. The dataset provides an important research and resource management tool and has been used for site assessments, conservation planning, spill response, and habitat capability modeling, including modeling for invasive species (e.g., green crab). Recently, the ShoreZone dataset was used during the major US-Canada oil spill response exercise held in Southeast AK.

**Ghost Fishing in the Southeastern Alaska Commercial Dungeness Crab Fishery**

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Entrapment of crabs by derelict pots (also known as ghost fishing) can be a significant consequence of commercial fishing operations. Prevalence of lost commercial pots and their instantaneous ghost fishing entrapments were estimated in the commercial Dungeness crab (*Cancer magister*) fishery in Southeast Alaska during the 2009 and 2010 summer closures of the commercial Dungeness crab fishery. Teams of divers were used to retrieve a random subsample of the pots that were located using side scan sonar. Densities of lost pots varied from 1 to 22 per km<sup>2</sup>, while entrapped Dungeness crab densities ranged from 0 to 25 per km<sup>2</sup> depending on the area surveyed. There was no statistical difference in ghost fishing rates between crab pots that were rigged with biodegradable escape mechanisms and those that were not. Overall, our findings show instantaneous entrapment of less than 2% of the annual commercial harvest. Calculation of the annual mortality level from instantaneous entrapment estimates would require knowing mortality and escape rates of entrapped crabs and the rate of pot re-baiting. Furthermore, the derelict crab pots were observed to effectively ghost fish for at least seven years, indicating long term cumulative impacts on Dungeness crab populations.

**Speakers: Gulf of Alaska**  
*Fish and Fish Habitat*

**Overwinter bioenergetic mechanisms for recruitment variability of Pacific herring (*Clupea pallasii*)**

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At high latitudes winter has the capability to influence the productivity of fish populations whose primary prey are influenced by seasonal production cycles. Food scarcity during winter can influence recruitment by reducing the number of recruiting juveniles or by reducing the fecundity of maturing adults. We examined the potential influence of winter on Pacific herring by contrasting the winter energy consumption of juveniles and adults from three stocks around the Gulf of Alaska. In addition we performed laboratory studies aimed at understanding how metabolic rates scale with temperature and estimating the energy cost associated with disease infection. These analyses indicated that the sensitivity of juvenile herring to winter varies spatially as a result of differences in food availability and sources of energetic costs. A direct consequence of this variation is that juveniles in different locations begin spring in different nutritional states. In addition, we determined that juvenile herring undergo compensatory growth in spring and the degree of compensation depends on the nutritional status at the end of winter. Laboratory studies demonstrate that the presence of disease in juvenile herring can impair compensation by imposing a metabolic cost. These factors likely interact to influence recruitment of juvenile herring into spawning populations and suggest recruitment models in stock assessments can be improved by monitoring juvenile condition and abundance. In contrast, winter appears to have less influence on the amount of energy allocated to gonadic tissues in adult herring.

**Population structure and sex identification in Pacific halibut (*Hippoglossus stenolepis*)  
from genomic and gene-linked microsatellites**

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With advances of molecular genetic techniques, research aimed at the identification of suitable management units has revealed surprisingly small scale population structure in many marine species. However, species with long pelagic phase or extensive adult migration are still presenting a significant challenge for genetic population identification. Increasing the number of markers, using samples from spawning aggregations when populations are most likely to segregate, and employing markers linked to genes that may show selective differentiation, improve the chances of detecting population structure in such species. However, when the signal of population differentiation is low, even slight biases in sampling may lead to spurious results. Here, we investigated the population structure of one such high dispersal species, Pacific halibut, by screening 16 genomic (random) microsatellites and 38 microsatellites linked to protein coding genes (ESTs) in samples from spawning aggregations collected from the Queen Charlotte Islands to Russia. Three of the genomic microsatellites were tightly linked to sex, allowing the correct sexing of >95% of individuals. Biases in sex ratios among samples would cause significant spatial differentiation if such sex linkage had remained undetected. Once sex was included in the analyses, the 16 genomic microsatellites revealed no spatial genetic structure. Analysis of the 38 EST loci is still ongoing but will be finalized by the time of the symposium. Our results to date suggest little spatial genetic differentiation among halibut spawning aggregations, but represent a reliable way of identifying sex at all life history stages of halibut.

**Speakers: Gulf of Alaska**  
*Seabirds*

**Post-Breeding Movements Of Kittlitz's Murrelet from the Gulf of Alaska  
and Aleutian Islands to the Arctic**

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Kittlitz's Murrelet (KIMU) is a rare seabird that nests in the coastal mountains of Alaska and often forages in glacially-influenced marine waters during summer. This species is of significant conservation concern, yet little is known about their post-breeding migration patterns and factors affecting them in their wintering habitat. We used solar-powered satellite transmitters (PTTs) to track 31 birds that were captured at four Gulf of Alaska (GOA) sites (Icy Bay, Glacier Bay, Prince William Sound, Kachemak Bay), and a single Aleutian Island (Atka Island) in 2009-2011. KIMU tagged in the GOA moved westward to the Alaska Peninsula after the breeding season. Three birds tagged in Prince William Sound moved further into the Bering Sea and then north into the southern Beaufort Sea. Two birds tagged at Atka Island crossed the shelf edge in the Bering Sea toward the Pribilof Islands and Nunivak Island. Among the three years, KIMU followed similar migratory pathways, but timing and endpoints differed, in part due to transmitter retention. Migrating birds typically traveled long distances in a short time, sometimes flying over land and at speeds of up to 85 km/hr. Post-breeding foraging locations were identified in lower Cook Inlet, southwest Kodiak Island, Port Heiden, and Point Lay. We speculate that KIMU observed during at-sea surveys along the ice edge during winter in the northern Bering Sea may include birds that migrate from the GOA in fall, perhaps reflecting a migration strategy that exploits productive glacial-marine waters in summer and productive sea ice-edge habitat in winter.

**Estimating demographic parameters to understand trend of the Kittlitz's Murrelet**

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The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is a rare seabird endemic to coastal Alaska and Russia that often occurs in glacially-influenced marine waters during the breeding season. Evidence of population declines coupled with recession of many of Alaska's tidewater glaciers prompted listing this species as a candidate to the U.S. Endangered Species Act. However, population trend estimates are variable and imprecise and, it is unclear whether the uncertainty reflects changes in demographic variability or simply movements of birds. We developed the first ever multistate models for this species to estimate survival, reproduction, and movements, using data from 150 radio-marked birds, relocated once every 1-3 days, during the breeding season in Icy Bay, Alaska, 2007-2011. Although daily movements were extensive, daily probabilities of a bird moving out of the bay (0.20) and into the bay (0.26) were similar and the daily probability of a bird leaving our study area completely was low (0.016). These results suggest that movement alone cannot explain the variability of population size and trend in our study area. The daily survival rate for a Kittlitz's Murrelet in Icy Bay was 0.997, extrapolating to a within-season survival rate of 0.84. Therefore, to maintain a stable population, 32% of the adult birds in this area need to reproduce successfully each year. However, annual nesting effort, based on radio-marked individuals, was ~17% and only 33% successfully fledged a single chick. Although range-wide trend estimates are variable, low adult survival with low reproductive success may substantiate uncertain declining trends of Kittlitz's Murrelets.

**Speakers: Gulf of Alaska**  
*Seabirds*

**Technical innovations for the census and monitoring of 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. Both species have apparently declined, but efforts to monitor populations are hindered by the difficulty in locating nests and low power to detect trends in at-sea vessel surveys. We report new methods for censusing and monitoring *Brachyramphus murrelets* in Alaska using radar and acoustic sensing, and compare results from these methods with concurrent at-sea counts in waters adjacent to nesting habitat. High-frequency marine radar is a standard tool for monitoring populations of marbled murrelets in forested watersheds south of Alaska, but requires modification for Alaskan conditions (two species with similar radar images; extended twilight flight activity; stronger winds). We tested radar for tracking murrelets flying to and from nest sites on Kodiak Island in 2010 and 2011 (2100 and 5000 detections, respectively), and in 2011 used a combination of radar and autonomous acoustic recording devices (981 hours of recordings). We assess the value of acoustic data (wingbeats and vocalizations) from flight paths and nesting habitat to determine species identity and complement radar counts. Marbled murrelets made up >99% of murrelets counted at sea in 2011, and concurrent radar counts confirmed that this species is primarily ground-nesting on Kodiak Island. The highest counts occurred in watersheds providing high-elevation, treeless habitat. The combined methods provide insights into murrelet behavior, seasonal attendance and habitat associations, and contribute to refining protocols for population censusing and monitoring.

**Speakers: Gulf of Alaska**  
*Mammals*

**Recolonization by sea otters, *Enhydra lutris*, in southern Southeast Alaska  
and implications for shellfish fisheries**

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Sea otters were extirpated by the fur trade from Southeast Alaska (SEAK) by the late 1800s. In the absence of sea otters, nearshore ecosystems changed, macroinvertebrate populations increased, and lucrative invertebrate fisheries developed. A successful reintroduction of sea otters between 1965-1969 resulted in a reoccupation of large areas of SEAK. Based on our 2010-11 aerial survey of SEAK, sea otters have both expanded their range and increased in number since the last survey in 2002-03. They are now distributed throughout much of the outer coast and have increased 12% yr<sup>-1</sup> in southern and 4% yr<sup>-1</sup> in northern SEAK. Since 1993 ADF&G has closed 21 dive fishery subdistricts within the red sea urchin, geoduck clam and California sea cucumber fisheries, due to presumed competition with sea otters. Additionally, the Dungeness crab fishery has experienced smaller landings, and competition with sea otters has been implicated. Using comparative foraging observations from 2010 and 2011 in areas that range in time since sea otter occupation, we found commercially important invertebrates represent a larger proportion of sea otter diets in areas more recently colonized. In May 2011 we captured 30 sea otters and implanted them with VHF radios to track their movements and foraging habits. Air and ground surveillance in 2011 has shown several of these instrumented otters are dispersing into previously unoccupied habitats. The population, movement and foraging data inform how this conservation success has, and will continue to, impact nearshore subsistence, sport and commercial invertebrate fisheries.

**Unraveling the mystery of harbor seal migration from a glacial fjord in southeastern Alaska**

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Harbor seals are one of a suite of upper-trophic level marine predators that occur in the eastern Gulf of Alaska and each summer thousands of seals aggregate in tidewater glacial fjords along the coast. Although it's well documented that approximately 15% of the harbor seals in Alaska utilize tidewater glacial fjords during the summer, movements beyond the boundaries of the fjords during the post-breeding season are unknown. Yet understanding habitat use and movements outside of the breeding season is critical for identifying threats, critical habitat, and annual fidelity. We deployed satellite-linked transmitters on juvenile and adult female harbor seals (n= 37) in Johns Hopkins Inlet (JHI) in Glacier Bay National Park (GB) to quantify post-breeding season distribution patterns of seals and to identify hotspots used by seals throughout the annual cycle. Seals undertook relatively extensive seasonal migratory movements throughout northern SEAK, the eastern Gulf of Alaska, and Prince William Sound with some seals ranging up to 900 km away. From September to February, 55% of seal hotspots occurred outside of GB in Icy Strait, Lynn Canal, and the eastern Gulf of Alaska and in some cases foraging areas of seals were associated with highly productive oceanographic features including submarine canyons and anti-cyclonic eddies. Although individual seals ranged far and wide during the post-breeding season, there was high degree of inter-annual site fidelity back to GB, the following breeding season for juvenile (88% return rate) and adult female (100% return rate) harbor seals which highlights the importance of understanding the spatial distribution of seals throughout the annual cycle.

**Speakers: Gulf of Alaska**  
*Mammals*

**Depth and range tracking of sperm whales in the Gulf of Alaska using a two-element vertical array, satellite and bioacoustic tags**

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Sperm whales consistently vocalize underwater, a fact that can be exploited to track their ranges and depths from fishing gear. This information can help determine distances whales will travel to depredate longlines. Unfortunately, traditional localization methods require multiple deployments of acoustic recorders, which fishermen find impractical. To determine whether long-range tracking using a single set of instruments is possible, a two-element vertical array was attached to a longline buoyline at 300m depth, off Southeast Alaska, between 15-17 August 2010. The buoyline also served as a test decoy, attracting seven sperm whales to the area. The vertical arrival angles and relative arrival times of all surface-reflected acoustic paths contain enough information for range-depth tracking without the need for mapping bottom bathymetry profiles. A ray-tracing program is used to model the acoustic travel times from each candidate source location, using a measured sound speed profile. Comparing modeled and measured time lags, an ambiguity surface was created, displaying the most probable whale position. On 15 August 2010 a whale was tagged with both a dive-depth satellite-linked transmitter and a bioacoustic datalogger. These attachments produced measurements of the animal's position, depth, and acoustic activity, thereby providing independent confirmation of the derived acoustic tracks. Preliminary results show that the depth and range of sperm whales can be accurately estimated up to at least 2km without knowledge of the sound speed profile. Field work supported by NOAA and analysis by 2011 NPRB graduate student fellowship research award.

**Speakers: Gulf of Alaska**  
*Mammals*

**Is real-time acoustic monitoring an effective mitigation measure for Cook Inlet beluga whales?**

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The Knik Arm Crossing (KAC) project is proposed to be built within critical habitat for endangered Cook Inlet beluga whales (CIBW). One planned mitigation measure to minimize potential impacts to CIBW is a construction monitoring program. Previous passive acoustic studies in Upper Cook Inlet indicate that acoustic detections of CIBW are often difficult due to the high ambient noise and potentially to the vocal behavior of CIBW. Additionally, visual observations of can be difficult because of the cryptic nature of this species (particularly younger, darker animals). A "proof of concept" study was designed to: (1) assess the effectiveness of acoustically detecting CIBW and (2) determine if 25X binoculars increased sighting rates and improved group counts and composition (compared to 7X binocular and naked eye observations). CIBW whistles and echolocation clicks were collected using an omnidirectional hydrophone (C75, CRT, Seattle, WA, USA) with a frequency response of 15 Hz to 95 kHz and real time acoustic monitoring software (SeaPro Bioacoustic Analysis, CIBRA, Italy). A land-based, visual observation team was used to confirm whale presence. There were 90 acoustic and 92 visual hours of effort over 14 days during 6-22 September 2011. A total of 15 encounters with CIBW occurred: 3 acoustic detections and 15 visual sightings. All CIBW were sighted before they were detected acoustically. The 25X binoculars enabled CIBW sightings at distances of over 4.8 NM. Results suggest that visual monitoring (with 25X binoculars) would be a more effective mitigation measure than acoustic monitoring during construction of the KAC project.

**Speakers: Gulf of Alaska**  
*Forward Thinking*

**Designing an Ocean Observing System for the Future: a Guide for Arctic Planning**

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The Alaska Ocean Observing System (AOOS) has developed a conceptual build out plan to describe coastal and ocean observing system needs in Alaska's Arctic, Bering Sea and Gulf of Alaska for the next 10 years. The plan will provide a basis for AOOS and its many partners to look for funding and collaboration opportunities to advance ocean observing in Alaska, and will be especially useful as part of the current planning processes for long term research and monitoring in the Arctic. The AOOS plan will be coordinated with plans developed by the other regional observing systems nationwide to present a comprehensive national picture of the regional needs for observing assets in the U.S. These plans focus on four core themes: Marine Operations; Climate Change and Variability; Water Quality, Ecosystem Health, and Fisheries; and Coastal Hazards. The AOOS plan has adopted an innovative spatially nested approach to address the themes, issues, and products across multiple spatial scales, thus allowing for implemented on a modular basis. The approach uses a 3-tiered system: 15 (or more) "Areas" of intensive observation with relatively fine scale modeling, nested within seven "Subregions" with more sparse observations and coarser scale modeling, nested within three Large Marine Ecosystems. Issues and products were identified for each theme by stakeholder/scientist workshops and interaction with outreach initiatives of other federal and state programs.

## Posters: Arctic

### Arctic - Ecosystem Perspectives

#### **The Use of 'Omic' Technologies to Study Microbial Response to North Slope Crude Oil in Alaska**

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Microbes are vital to marine ecosystems constituting the base of the food web and performing essential processes such as oxygen generation, nitrogen fixation, and nutrient recycling. In addition, microbes serve to remove pollutants through the process of biodegradation. Specifically, the timelines and biological processes of petroleum biodegradation in marine ecosystems are yet to be fully appreciated. Previous studies from our laboratory have demonstrated that hydrocarbon-degrading bacteria and related functional genes exist in several distinct global locations. This investigation serves to evaluate the impact on microbial communities in sediment samples exposed to North Slope crude oil. To achieve this goal, baseline microbial populations in marine sediment samples collected in the vicinity of Barrow, Alaska were characterized through metagenomic, metatranscriptomic, and metaproteomic approaches. These techniques involve the study of the genetic sequence profile (metagenomics), genetic expression profile (metatranscriptomics), and protein function profile (metaproteomics) of entire microbial communities. The microbial response to North Slope crude oil exposure was measured using these three 'omic' techniques to determine perturbations in microbial diversity, gene expression, and protein functional content. Results of this study demonstrate the utility of 'omic' technologies to characterize microbial diversity and function in response to exposure to hydrocarbons. These findings can be applied to future investigations and predictions of recovery from hydrocarbon exposure to determine the potential for petroleum biodegradation as well as the timelines associated with return to microbial baseline diversity and function.

#### **Estimating Mean Predator Diet Composition Using Fatty Acid Signature Data**

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Information on diet composition provides insights into numerous facets of ecology, including regulatory mechanisms, community structure and stability, the transfer of energy, nutrients, and contaminants between trophic levels, and predicting the potential impacts of ecosystem perturbations. Quantitative fatty acid signature analysis (QFASA) has emerged as a common method of estimating diet composition, especially in marine ecosystems with diverse fatty acids. QFASA estimates the diet compositions of individual predators. However, individual diets might be best viewed as deviations from the mean diet of a class of predators, with classes potentially defined by demographic, spatial, or temporal covariates. Mean diets are currently estimated as the within-class average of estimates for individual predators. Such a two-stage estimator may not be optimal. A modified estimator is proposed in which mean diet proportions are the parameters of a mixture model, thereby estimating mean diet directly. In addition, variances are currently estimated using a combination of within-predator variances estimated via bootstrapping and observed between-predator variance. A full bootstrap estimator is proposed as an alternative. The statistical properties of the proposed estimators are investigated using computer simulation. The proposed estimator of mean diet composition tends to have less bias than the current estimator, although between-sample variability tends to be greater. The bootstrap estimator of variance is consistently comparable or superior to the current variance estimator, which can be either positively or negatively biased. The proposed estimators advance QFASA methodology and may enhance its utility in diet studies of marine species throughout Alaska.

**Biogeochemical indicators of change in Arctic and Subarctic marine bird communities:  
Alaska and Greenland**

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Understanding the complex dynamics of environmental change in northern latitudes is of paramount importance today, given documented rapid shifts in sea ice, plant phenology, temperatures, deglaciation, and habitat fidelity. This knowledge is particularly critical for Arctic avian communities, which are integral components by which biological teleconnections are maintained between the mid and northern latitudes. Furthermore, Arctic birds are fundamental to Native subsistence lifestyles and a focus for conservation activities. Since 2009, we have been studying the foodweb ecology using stable isotopes ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ ,  $\delta^{34}\text{S}$ ) of contemporaneous coastal and marine bird communities in High Arctic (Northwest Greenland) and Low Arctic (western Aleutian Islands, AK). We are quantifying the isotopic values of blood, organ tissues, and feathers, and have carried out comparisons between native and lipid-extracted samples. 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  $\delta^{15}\text{N}$  compared to their Low Arctic counterparts, but  $\delta^{13}\text{C}$  values are similar in both regions. These patterns follow observed regional differences in Arctic isoscapes, and 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. For example, Aleutian birds feeding in upper trophic levels have tissues more enriched in both  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  compared to specimens collected in 2000-2001. We anticipate broadening the time depth of this initial study using museum archival and archeological material, as well as continuing studies in 2013 and 2014.

**Alaska Monitoring and Assessment Program (AKMAP): Preliminary findings from the coastal  
northeastern Chukchi Sea, 2010–2011**

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The Alaska Department of Environmental Conservation (ADEC) and University of Alaska School of Fisheries and Ocean Sciences, Fairbanks (SFOS), established an Alaska Monitoring and Assessment Program (AKMAP) focused on conducting aquatic-resource surveys of Alaska's waters. ADEC and SFOS conducted research cruises in the fall of 2010 and 2011 to survey and monitor the state of the Chukchi Sea coastal environment. The purpose of this survey was to assess the water quality and ecological status of waters of the northeastern Chukchi Sea, from Pt. Hope to Barrow, in waters 10–50 m in depth within the Beaufort/Chukchi coastal-shelf ecosystem. The 2-year survey was conducted aboard the R/V Norseman II. We sampled 64 stations with the following activities accomplished at most stations: CTD/WQ; plankton tow; drop camera; van Veen grab for sediment chemistry & macroinvertebrates; beam and otter trawls; biological-contaminant samples; and sediment- and biological-isotope samples. We also conducted surveys for marine birds and mammals during transit between stations. The AKMAP assessment estimated the spatial extent of water quality based on stressors such as contaminants, water-quality parameters (pH, temperatures, salinity, and dissolved oxygen), and upper trophic level taxa such as benthic fishes and marine birds and mammals. Environmental managers will use this information to support the protection and restoration of coastal marine environments, mitigate damage to the marine ecosystem, and implement discharge-monitoring requirements in NPDES permits. Findings are anticipated to be available by late 2012.

### **Regional Shoreline Change Studies, North Slope Coast of Alaska**

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Since 2006, the U.S. Geological Survey's (USGS) Coastal and Marine Geology Program has been leading a comprehensive study to document and evaluate rates and causes of coastal change on a regional scale using historical maps, charts, aerial photography, and satellite imagery. Average shoreline change rates and ranges from 1947 to the mid-2000s were determined every 50 meters between Barrow and the U.S.-Canadian border. Results show that shoreline change rates are highly variable along the coast, with an average regional shoreline change rate of -2.0 m/yr and localized rates of up to -19 m/yr. The highest erosion rates were observed at headlands, points, and breached thermokarst lakes. Areas of accretion were limited, and generally associated with spit extension and minor beach accretion. In general, erosion rates increase from east to west, with overall higher rates east of Harrison Bay.

In addition to documenting and evaluating long-term coastal erosion, our research focuses on documenting the current state of the Alaskan Arctic coast by collecting a benchmark high-resolution airborne topographic lidar-elevation dataset which can be used to compare past to present coastal configurations as well as to provide a framework for the quantitative assessment of other coastal hazards such as storm-surge and coastal flooding. Here we present preliminary results of storm-surge inundation modeling and ground-truth results of the lidar survey from the permafrost bluffs bordering the village of Kaktovik on Barter Island, Alaska.

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

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The Synthesis of Arctic Research (SOAR) purpose is to bring together a multidisciplinary group of Arctic scientists to explore and integrate information from completed and ongoing marine research in the Pacific Arctic ([www.arctic.noaa.gov/soar](http://www.arctic.noaa.gov/soar)). Supported by a MOU between BOEM-Alaska Region and NOAA-PMEL, the synthesis is guided by a 13-member Science Steering Committee formed of senior scientists and local residents with decades-long experience in ecosystem and resource management in the Pacific Arctic. The first annual meeting of the SSC was held in November. Science themes were developed which will guide integration of research into a series of peer-reviewed publications. A larger SOAR workshop with invited contributors will be held in spring 2012. Workshop participants will inventory available data and evaluate its sufficiency to address specific cross-disciplinary hypotheses. Teams will be formed to target each science theme and will meet both independently and as a group to achieve SOAR goals. The synthesis will be completed in 2016, providing important information to management decision-makers and guiding future research activities.

**The Barents and Chukchi Seas Compared:  
Why does the Barents Sea support more upper trophic level biomass?**

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The Barents and Chukchi Seas are high latitude, seasonally ice covered, and have strongly advective regimes, but differ remarkably in biomass of fish, seabirds and marine mammals. Both seas receive water from the south; water entering the Barents comes from the deep, ice-free and "warm" Norwegian Sea, and contains a rich supply of zooplankton that supports larval fish in spring. Bering Sea Water entering the Chukchi in spring is depleted of zooplankton and cold, having traversed the shallow ice-covered northern Bering Sea in winter. Marine mammals in the Barents are mostly planktivorous and piscivorous, whereas in the Chukchi, most are benthic-foraging. Fish biomass is three orders of magnitude greater in the Barents than in the Chukchi. If climate change warms the Barents reducing ice cover, productivity is likely to increase. In the Chukchi, warming should also reduce sea ice cover, permitting a longer production season. However, the shallow northern Bering Sea will continue to be ice-covered in winter, so water entering the Chukchi in spring will be cold, and likely will continue to be a barrier to the movement of temperate fish into the Chukchi.

**Recovery in high arctic kelp communities**

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High arctic kelp communities in Prudhoe Bay are considered sensitive habitats and have the potential of being impacted by oil and gas activities. Impacts can result in the removal or scouring of sessile organisms leaving open space for new recruitment or damaged organisms needing to recover. This project focused on acquiring a better understanding of 1) how fast sessile communities recover after disturbances and 2) which mechanisms are most successful in recovery. Specifically, recruitment of all sessile organisms was monitored for seven years following complete clearings of all organisms on tagged rocks. In addition to this, regrowth rates were monitored for damaged sponges, foliose red algae, and encrusting coralline algae. For regrowth, small clearings were made in the center of various organisms and regrowth was monitored over time. This study found that overall recovery on completely cleared rocks was very slow. After seven years, less than 5% of the bare space had newly recruited organisms. This study also demonstrated that regrowth was a much more successful way for certain organisms to recovery after a disturbance. In the partial clearings, sponges completely regrew and corallines regrew almost 40% after three years. There was no noticeable difference in the regrowth of the foliose red algae. This study has shown that the boulder areas in Prudhoe Bay are vulnerable to impacts that remove or damage sessile organisms and as such, these types of disturbances should be avoided.

### **Arctic Landscape Conservation Cooperative Coastal Process Studies**

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The goals of the Arctic Landscape Conservation Cooperative (ALCC) include 1) obtain a better understanding of how climate change and other landscape-scale stressors affect ecosystem processes, 2) assess the effects of environmental change on access to subsistence resources, and 3) improve data management and integration for the benefit of resource managers and the conservation community as a whole. The coastal zone sustains important fish and wildlife populations and provides a crucial resource base for coastal communities. The ALCC convened a Coastal Process Work Group to identify activities that would address science and information priorities identified in existing agency documents. The Work Group made recommendations in the broad areas of data synthesis and compilation, environmental monitoring, and model development; these will guide future ALCC efforts. Currently, the ALCC is conducting several coastal projects, including "Modeling Arctic barrier island-lagoon system response to projected arctic warming." This study investigates historical trends in barrier island migration rates, shoreline change, inundation of coastal wet sedge, and the relative importance of processes responsible for those changes. This study will determine dominant forces responsible for projected changes to the arctic coastal landscape, and to assess the likelihood of Arctic barrier island-lagoon system habitat inundation by seawater in response to changing ocean conditions. Another project investigates how melting of glaciers in the eastern Brooks Range may affect the ecology of the nearshore marine environment, because of changes to the quantity of sediment, nutrients, and carbon delivered to estuarine areas.

### **Measuring Arctic zooplankton advection in the Bering and Chukchi Seas**

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Pathways of zooplankton advection through the Bering Strait and along the Chukchi and Beaufort shelves may be indicators of bowhead whale migration routes, aggregation trends, and feeding patterns. 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 *Thysanoessa raschii* and *T. inermis*. These euphausiid species have been found in the stomachs of bowhead whales near Barrow, and in the Beaufort Sea, but are not believed to be self sustaining in the Alaskan Arctic. It is proposed that the euphausiid population of the Beaufort Sea originates in the Bering Sea, and is then advected through the Bering Strait, with an average minimum advection time of about four months. Seven years of data (2002-2009) from an ADCP mooring in the eastern Bering Strait are analyzed to identify timing of highest acoustic backscatter, as well as to compare relative amplitude between years as a proxy for zooplankton abundance. The increase of zooplankton DVM activity observed during spring at the Bering Strait mooring for all years agrees with the four month transport period required for these organisms to arrive on the Beaufort Shelf during the fall. Additionally, abundance was highest during the 2004-2006 years and lowest during 2008-2009. Ongoing comparisons to wind and current conditions during these time periods, and comparison to data from other moorings in the region will further improve our understanding of euphausiids in this region.

**Using web-mapping technologies to improve oil spill preparedness and response in the Arctic**

**Amy Merten**, amy.merten@noaa.gov, NOAA Office of Response and Restoration

The Environmental Management Response Application (ERMA) is a powerful web-based Geographic Information System (GIS) tool that displays oil spill information in the context of real-time conditions, and sensitive species information to quickly decision-making and data sharing. NOAA is working with Federal, state, tribal and local partners to develop ERMA for the Arctic to prepare for oil spill response, assessment, and restoration. Through the development of Arctic ERMA, NOAA will help support the spill response capacity of the U.S. Coast Guard, industry first responders and other Arctic stakeholders including coastal communities, Alaska Native villages, and the State of Alaska. Interested parties will be able to use the ERMA interface not only to address oil spill planning and response, but also to assess sea-ice conditions and shoreline erosion information. NOAA is using Arctic ERMA as a pilot platform for the Arctic Council's Emergency Prevention, Preparedness and Response Working Group. This presentation will review the progress of Arctic ERMA development, identify opportunities for collaboration, and provide a first look at compiled data, interface and utility of this powerful tool. NOAA deployed ERMA for the Deepwater Horizon disaster and provided a public version of the site. Lessons-learned have been applied to the Arctic ERMA site and will be discussed as appropriate.

Arctic - Ecosystem Perspectives

**A year in the life of the bowhead whale: an educational outreach product in calendar format**

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Aspects of bowhead whale life history and behavior are presented as monthly panels of a year-long calendar.

**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. Towards 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 U.S. arctic environmental change science community in international and global change research initiatives. Specific SEARCH activities include: (1) Arctic Observing Network (AON), (2) Arctic Sea Ice Outlook, (3) Sea Ice for Walrus Outlook, (4) Developing recommendations for an interagency "Understanding Arctic Change" program.

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>.

### **NOAA-Shell/ConocoPhillips/Statoil Data Sharing Memorandum of Agreement**

**Amy Holman**, amy.holman@noaa.gov, National Oceanic & Atmospheric Administration

NOAA, Shell Exploration & Production, ConocoPhillips, and Statoil USA E&P Inc. signed Memorandum of Agreement (MOA) in August 2011 to enhance collaboration on ocean, coastal and climate science for the Arctic. The outcome of the effort is focused on developing a better understanding of the physical processes governing sea ice, the atmosphere, and the ecological character of the coastal and ocean Arctic region in order to further inform effective societal, economic and environmental decision-making regarding Arctic resource utilization. The MOA is intended to build upon existing strong relationships based on common interests, assist in devising company and agency strategy, and help manage critical environmental issues efficiently and effectively. This poster provides information on the Agreement and the types of information and data the parties have agreed to share with the public.

### **National Ocean Council Arctic Strategic Action Plan**

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The National Policy for the Stewardship of the Ocean, our Coasts, and the Great Lakes prioritizes nine objectives to address some of the most pressing challenges facing these precious resources. Addressing environmental stewardship needs in the Arctic Ocean and adjacent coastal areas in the face of climate-induced and other environmental changes is one of the nine. For each objective, the National Ocean Council is overseeing development of strategic action plans (SAP). These plans identify specific and measurable near-term, mid-term, and long-term actions, with appropriate milestones, performance measures, and outcomes, to meet each priority objective. In addition, each plan will explicitly identify key lead and participating agencies; gaps and needs in science and technology; potential resource requirements and efficiencies; and steps for integrating or coordinating current and out-year budgets. This poster will describe the areas of focus within the Arctic SAP and highlight key agency actions for implementation over the next several years.

**Observations and Implications of Climate Change in Subsistence Fishing Communities in Northwest Alaska**

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While the political dimensions of global climate change continue to produce debate, a scientific consensus has emerged that global temperatures are increasing with particularly dramatic changes occurring in arctic ecosystems. There is a clear perception among residents of the Arctic that the climate of the region has changed in living memory. Observations of warmer temperatures, longer growing seasons, and later freeze-up of major waterways have been reported repeatedly by indigenous people throughout the region, even before trends became statistically detectable in local instrument records. Based on over 50 key informant interviews and detailed participant observation of subsistence fishing practices, this poster presents the observations of climate change noticed by elders and expert subsistence fishers in the communities of Noatak, Selawik, and Shungnak in northwest Alaska. Shifts in water levels, changes in fish abundance, distribution and movements, and less predictable and abnormal weather and seasonal patterns are among the most commonly noticed changes. We compare the level of agreement about these observations and their implications using cultural consensus analysis. Our interview data strongly suggest that a study of climate change observations and impacts is insufficient without an analysis of pronounced sociocultural and economic changes also being experienced in rural arctic Alaska.

**Seven-year old Arctic marine data; is it too old for climate negotiations?**

**Tom Dunning Newbury**, newbury.alaska@mtaonline.net, UN Climate Change Conferences

This presentation is about the USE of Arctic marine data rather than the collection and/or analysis of field data. It is about the use in specifically the draft UN Negotiating Text for climate-change negotiations. The draft text refers to the UN Intergovernmental Panel on Climate Change (IPCC), stating that cuts in global emissions are required ". . . as documented by the IPCC Fourth Assessment Report . . ." So, I examined the UN and IPCC procedures to determine if they inadvertently restrict the amount of up-to-date Arctic marine data in climate negotiations. I examined the most recent IPCC assessment--the Fourth Assessment Report (AR4). It was published in 2007, and the IPCC practice of referencing only peer-reviewed information meant that the assessment included publications through only 2005. Preparation of the Assessment Reports requires so much time that the IPCC usually publishes them only every five-to-seven years. The next Assessment Report (AR5) is being prepared, but won't be published until 2013-14. One result of the long time span is that the draft Negotiating Text will be based on 2005 Arctic marine data until 2013-14. A conclusion is that this is inadequate, especially for formerly ice-covered areas. Another conclusion is that the long time span increases the importance of interim updates, such as the annual NOAA Arctic Report Cards. A third conclusion is that all marine science reports relating to climate change should include some type of international peer review.

### **From North to North: Outreach and Educational Opportunities on the North Slope**

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The North Slope Borough Department of Wildlife Management (NSB-DWM) has increased outreach efforts to the residents of the NSB, developing greater awareness for studies concerning subsistence resources. We produce a newsletter twice a year, highlighting current projects and issues of interest to the public. Details about DWM projects and other projects are provided on the NSB website ([www.north-slope.org/departments/wildlife/](http://www.north-slope.org/departments/wildlife/)). For more time-sensitive information such as community meetings, public hearings, and real-time wildlife issues, flyers and emails are distributed broadly, including on DWM's Facebook page; radio announcements are aired, and radio call-in shows allow for real-time dialogue and feedback from residents. Finally, we provide educational opportunities for NSB students as an important component of our outreach effort. We deliver information to NSB schools, provide guest speakers, and mentor students on science projects. Scientific exchange programs between North Slope students and outside research entities, such as Mystic Aquarium and Sitka WhaleFest/Scientist in Schools, have been successful in allowing young people to learn how science is used to gain a better understanding of our subsistence resources. These programs are designed to encourage North Slope students to explore science as a career. The success of this pilot program is opening the door for similar collaboration with other research entities, such as Colorado State University. We also provide internship opportunities for NSB college students interested in working with the DWM in the future. These educational efforts increase student awareness of subsistence resources and support the NSB in "growing our own scientists."

### **Iñalit Traditional Knowledge of Walrus in the Bering Strait**

**Julie Raymond-Yakobian**, juliery@kawerak.org, Kawerak, Inc.

Native subsistence communities in the Bering Strait islands (Little Diomed, Saint Lawrence) continue to rely on walrus for food, equipment, and cultural significance. This project documents Diomed hunters and elders local and traditional ecological and cultural knowledge of Pacific walrus. Documentation of this information while it still in use is of crucial importance and this includes information about the distribution, abundance and/or availability of walrus relative to ice conditions and time of year; overall health, and other indices to population status; walrus food habits; walrus hunting practices; usage of walrus on Little Diomed Island; changes over time to all of the above variables; and changes in historical harvest levels that may have triggered changes in the socioeconomic and subsistence lifestyle of the community. Data are being gathered using a semi-structured oral interview protocol, often in the Iñalit dialect, that includes an interview guide. To date, interviews have been conducted with eight current and former Diomed residents, with additional interview work ongoing. This project is needed to provide hunters and elders an opportunity to document and share their knowledge of walrus and their social, cultural, and economic value, in contemporary life. It is anticipated the information collected through this project will be valuable not only to Diomed residents, but also for the entities involved in the creation and enforcement of marine and marine mammal policy and management strategies during a time of dramatic climactic change.

### **An Interdisciplinary Description of the Elson Lagoon Subsistence Fishery**

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Elson Lagoon is a brackish embayment near Barrow which is utilized by residents for many subsistence purposes, one of which is fishing. Gillnet fishing is done in summer months to provide for personal use and to share with the community. The primary species harvested include least cisco, broad whitefish, pink and chum salmon. Since 1989 the North Slope Borough has been documenting the total net effort and catch composition. Catch composition has also been collected for select years. In order to quantify the catch composition, the North Slope Borough Department of Wildlife Management has implemented an annual logbook program in which several local fishermen keep a record of their catch throughout the season. The Dept. of Wildlife Mgmt. also conducts regular net surveys wherein nets are counted throughout the fishing season, which typically lasts from June to October. Results of the 2010 Net Survey and Catch Composition will be presented showing possible changes to the fishery compared to previous years. Ethnographic information was also compiled to understand the history of the fisheries in Elson Lagoon. Oral history indicates fishing activity has existed in Elson Lagoon for generations and fishing sites are passed down between generations. A holistic view of the fishery is presented through analysis of the net effort, catch composition, and a rich ethnography provided by fishermen. It is only by seeing the fishery through an interdisciplinary lens that the importance of this resource is understood.

### **A Promising Tool for Subsurface Permafrost Mapping: An Application of Airborne Geophysics**

**Jared Abraham**, jdabraha@usgs.gov, United States Geological Survey

Permafrost is a predominant physical feature of the Earth's Arctic and Subarctic clines and a major consideration encompassing ecosystem structure to infrastructure engineering and placement. Perennially frozen ground is estimated to cover about 85 percent of the state of Alaska where northern reaches are underlain with continuous permafrost and parts of interior Alaska are underlain by areas of discontinuous and (or) sporadic permafrost. Effective mapping of discontinuous permafrost at scales meaningful ecologically and (or) from an engineering perspective has been a long-standing challenge. A better understanding of the dynamic distribution and physical properties of permafrost, from continuous to discontinuous, will provide knowledge of how the permafrost environment may change in the future and help inform engineering and natural resource response strategies from interior to coastal zones. In June 2010, the U.S. Geological Survey conducted an airborne electromagnetic survey near Fort Yukon, Alaska. To develop new approaches to map and model the distribution of permafrost for improved groundwater models. The methodologies have far-reaching ecological and engineering applications. This work provides an approach to examine the three-dimensional (3-D) distribution of permafrost and is a demonstration of the application of airborne electromagnetics to permafrost mapping. Both interior 3-D examples and coastal imaging will be presented.

### **A Winter Expedition to Explore the Biological and Physical Conditions of the Bering, Chukchi, and Southern Beaufort Seas**

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Our understanding of seasonality, particularly winter conditions, in the Arctic is severely limited. This lack of knowledge has compromised our ability to model and to predict Arctic ecosystems, knowledge critical to our efforts to understand the potential impacts of ongoing climate change. In November-December 2011 we will be conducting a cruise on the USCGC Healy to the Bering, Chukchi, and Beaufort Seas. We have identified a set of key transects in the various cross-shelf-slope regimes along which we will conduct physical (hydrography, circulation), chemical (nutrients, dissolved organic matter), and biological (zooplankton, microzooplankton, chlorophyll, marine bird) sampling. Our objectives include describing hydrography, circulation, and aspects of the planktonic, nutrient, and dissolved organic matter environments, identifying the overwintering habitat of *Calanus* spp. and overwintering strategies of phytoplankton, determining the condition and activity (respiration) of *Calanus* spp., euphausiids, bacteria, and phytoplankton, and quantifying the coarse- and fine-scale vertical distributions of plankton and particles in relation to the vertical structure of the water column. Here we present preliminary findings on the hydrography and aspects of the biology from the winter cruise.

**Sea Ice Forecasting - How NOAA Might Do It Better!**

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The recent changes in Arctic sea ice, notably thinning, reduced summer extent, and longer open water periods, offer the potential for greater human presence in the Arctic and increased stress on ice-dependent species, coastal communities, and subsistence hunters. Sea ice changes also may have a role in regulating Arctic and sub-arctic weather and climate. In response, the National Oceanic and Atmospheric Administration (NOAA) has declared that "sea ice forecasting" is a priority for the future. After consulting with internal and external experts, NOAA has prepared a draft implementation plan that describes what it intends to do over the next three years to improve sea ice forecasts at three temporal scales, and their delivery to users. The presentation summarizes the plan and invites feedback.

**Climate change impacts on storm surge levels affecting habitats within a barrier-island lagoon system in eastern Arctic Alaska**

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Changes in Arctic coastal ecosystems as a result of global warming may be some of the most severe on the planet. A better understanding and scientific analysis of the rates at which these changes are expected to occur over the coming decades is crucial in order to provide science-based information to resource managers. In this Arctic Landscape Conservation Cooperative (ALCC) study, we investigate the potential for changes in flooding extents and frequency affecting barrier-island and wet sedge habitats in Arey Lagoon, a barrier-island lagoon system known to provide nesting habitats for numerous migratory bird species.

A suite of field data (e.g., waves, currents, water levels, salinity, sediment grain size, active and upper permafrost layer temperatures) was collected during the 2011 open-water season (July through September) to provide baseline information and to support a numerical modeling effort aimed at understanding the physical processes driving barrier island degradation/migration as well inundation, including that of a wet sedge area on the mainland coast within the Arey Lagoon system. Field observations and measurements show that habitats on the barrier island and wet sedge area are prone to storm surge inundation driven by polar lows, frontal cyclones, and westerly winds. In the absence of storm inundation, freshwater ponds fronting the lagoon became increasingly brackish with time indicating that the ponds and lagoon are hydraulically connected. These measurements, in combination with model simulations forced by projected barometric pressures and wind systems, provide crucial information for assessing potential for habitat migration in the coming century.

**Coupled sea-ice/ocean numerical simulations of the Chukchi and Beaufort Seas**

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A coupled, regional sea-ice/ocean model is being developed to examine the interannual to interdecadal variability of circulation, sea-ice extent, thickness and concentration within the Chukchi and Beaufort Seas for the period 1985-2006. Our coupled model is based on the Regional Ocean Modeling System (ROMS), with a resolution of 5 km along the Northern Alaska coast. Preliminary results and the solution technique will be described. One novel aspect is the use of a landfast ice climatology to lock the ice in place along the Beaufort coast in winter.

The model results will ultimately be compared to the available observations of currents, temperature, salinity and sea ice extent. Some of the current measurements were taken under the landfast ice, where the currents behave quite differently than those under the mobile sea ice.

**Ocean waves conditions in the Chukchi Sea from satellite and in situ observations: necessity for the observations and numerical modeling**

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The temperature observations in the Chukchi Sea collected since 1941-present have been analyzed through a self-consistent data recovering EOF algorithm. EOF's analysis identifies "cold", "normal", and "warm" states. We also found that temperature gradually increases 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 in temperature is almost twice as small. It is minimal (0.2-0.5C) in the Long Strait and uniform (0.7-1C) for remaining regions. The analysis of the sea surface height anomaly shows that during the "warm" periods there is a stronger flow through the Bering Strait and intensified current (15-20cm/s) along the Siberian coast towards the Long Strait. The extensive correlation analysis shows 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.

### **Lead and landfast sea ice patterns in the Chukchi and Beaufort seas over the past two decades**

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The Chukchi and Beaufort seas have experienced dramatic reductions in sea ice extent in recent decades as the perennial sea ice cover of the Arctic as a whole has retreated. At the same time there has been growing commercial interest in offshore oil and gas development, with leases covering approximately 1.1 million hectares on the outer continental shelf sold to 7 different companies in 2008. This has created the need to better understand the sea ice regime in this part of the Arctic in terms of its seasonality, lead patterns and the spatio-temporal distribution of landfast ice. Here we present an updated analysis of landfast ice extent, duration and seasonality in the Beaufort Sea from 1996-2008 and compare it with a newly derived dataset covering the same time period in the Chukchi Sea. Although landfast sea ice in both seas exhibits the same characteristic asymmetric annual cycle of gradual advance and rapid retreat, we identify significant regional differences. We attribute these in part to coastal and bathymetric configurations in the Chukchi Sea that are not found in the Beaufort Sea. We also present a comparative, qualitative analysis of lead patterns in both seas, focusing on differences and commonalities. Sea ice in the Chukchi Sea is more mobile than that in the Beaufort Sea, partly because of thinner ice, and partly because there is the opportunity for coastal polynya formation under any wind except those from the North. Hence, when winds change there will often be open water for the ice to move into. As a consequence, lead patterns in the Chukchi are shorter-lived than in the Beaufort. Despite more complicated lead patterns, topographic constraints, such as the presence of Wrangell Island to the West and the convergence of coastlines towards Bering Strait, can help explain recurrence patterns in lead distributions. We also identify open water associated with offshore shoals in the Chukchi Sea, where grounded ridges can form hundreds of kilometers from the coast. These grounded ridges create small polynyas, which can be observed in satellite imagery and can affect lead patterns throughout the region.

### **Surface Currents in the Northeast Chukchi Sea**

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It has been well documented that the vertically averaged flow throughout the northeast Chukchi Sea is north/northeast, because of the large-scale pressure gradient between the Pacific and Arctic oceans. Mean winds over the shelf are from the northeast, opposing the pressure gradient. Contrasting wind and current directions imply varying surface and sub-surface flows within the water column; however, due to the absence of reliable measurements of the surface flow in the Chukchi Sea, these differences have not been adequately defined.

A three-year field effort has been underway to examine the circulation of the northeast Chukchi Sea. High-Frequency Radar (HFR), used to map surface currents, is one component of this effort, in addition to glider transects and a six mooring array. During the open water seasons of 2009 through 2011, surface currents in the northeast Chukchi Sea were measured within 200 km of the coastline at 6 km resolution using shore-based HFR systems in Barrow, Wainwright, and Point Lay, Alaska. Data collected are representative of the upper 2 m of the water column over an area of approximately 30,000 km<sup>2</sup>.

Inter-annual comparisons will be presented, as will detailed descriptions of major circulation features, such as the Chukchi coastal current and the presence of mesoscale eddies, in addition to wind/current relationships, regions of convergence/divergence, and surface transport estimates. Comparisons of HFR returns and surface drifter data will also be presented.

**Wind Field Climatology, Changes, and Extremes in the Chukchi/Beaufort Seas and Alaska North Slope during 1979-2009**

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Wind field climatology and extremes at ~32 km resolution were analyzed for the Chukchi/Beaufort Seas and Alaska North Slope region with the 3-hourly North American Regional Reanalysis (NARR) for the period of 1979-2009. The monthly average wind speeds in the study area show a clear seasonal cycle with a minimum of 2-4 m/s in May and a maximum up to 9 m/s in October. The 95th percentile wind speeds also show a similar seasonality with a maximum up to 15 m/s in October. The 31-year domain averaged 3-hourly wind speeds display a clear diurnal cycle over land and sea ice areas during the warm seasons. Weaker radiation forcing during winter and larger heat capacity over open water reduce the diurnal signal in the wind field daily variations. There are increasing trends of area averaged monthly mean and 95th percentile wind speeds during the months of July through November over the 31-year study period. The strongest increase in the 95th percentile wind speeds occurs in October from 7 m/s in 1979 to 10.5 m/s in 2009. The frequency of extreme wind events (wind speed above the 95th percentile winds) also shows an increasing trend in all months. Again the greatest frequency increase occurs in October, when there are 8% more extreme wind events in 2009 comparing to 1979. The wind direction climatology analyses show that the prevailing wind direction in the study area is northeast with a frequency 40%-60% for most of the year. The frequency for southwest and northwest winds is small (<20%) except two anomalous areas along the Brooks Range in Alaska and the Chukotka Mountains in Far East Russia where the frequency enhances to 35-50% during the cold season months. The extremely stable airflow plus the mountain barrier effect cause these mesoscale features in the wind direction climatology.

**Sea Ice Response to Atmospheric Storms**

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Episodes of increased near-inertial motion have been observed in the ice-covered winter Arctic ocean, suggesting sea ice may act as a link in the energy cascade from atmosphere into the ocean. The response of sea ice to atmospheric storms is examined using data from a moored array deployed on the Beaufort continental slope from August 2008-August 2009 and reanalysis winds. Many storms occur during the Arctic winter, but not all of these create an ice response. However, three unusually strong storms passed near the array in November, December and March. These events were accompanied by high levels of inertial energy in the ice coupled to storm tracks that passed near the array itself. In addition, internal wave energy was observed radiating from the surface to depth during the November event, suggesting energy from these storms is able to penetrate into the ocean interior. The ice response to atmospheric forcing in this region is predominantly controlled by ice mechanics. However, the "perfect storm" event consisting of the proper ground velocity and track is able to overcome these mechanics and excite the ice. Storm characteristics, which caused wind directions to switch over the array in an inertial period (~12.62 hours), had the biggest impact on sea ice inertial response.

**R/V Sikuliaq: A New Ice-capable Resource for Research in Alaskan Waters**

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The research vessel R/V Sikuliaq is currently being constructed on behalf of the NSF to support future scientific studies in high latitude waters. The 261 foot global class vessel will be capable of breaking 2.5 foot thick ice at 2 knots with an endurance of 45 days at sea and cruising at 11 knots. The R/V Sikuliaq will have a beam of 52 feet and a draft of 18.9 feet that will carry 26 scientists and a crew of 20. Berthing accommodations are a combination of single/double rooms with one stateroom and the common areas of the vessel are designed for ADA access and accommodations. The total laboratory space (main, analytical, electronics, wet, upper, and Baltic room) will be 2100 square feet. The 4360 square foot working deck that is approximately 70 feet in length will accommodate 2-4 vans and multiple science operations. The vessel design strives to have the lowest possible environmental impact, including a low underwater-radiated noise signature. The science systems are prescribed to be state-of-the-art for bottom mapping, over-the-side "hands free" gear handling, broad band communications and scientific walk-in freezer and environmental chamber. More details and photos of the construction progress are available on the website at [www.sfos.uaf.edu/arrv](http://www.sfos.uaf.edu/arrv). The tentative shipyard schedule has a launch date of June 2012 and delivery to the University of Alaska Fairbanks in June 2013. Scientific operations following trials and testing is planned to start in early 2014.

**AUV Glider and HF Radar observations of circulation and stratification features in the Chukchi Sea**

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We present unique high-resolution time-dependent observations of circulation and stratification features in the Chukchi Sea from AUV gliders and HF radars. The observations highlight a complex flow field and concurrent stratification changes that influence both the physical, biological and chemical structure of the ocean on different time and space scales. Wind and buoyancy forcing drives strong nearshore flow, which together with topographic steering creates confluence, divergence and eddies in the flow field. Stratification changes are large and are associated with both flow field anomalies and storm events. These observations show a more complex, dynamic and high-energy ocean environment than previously reported in this area.

**High Resolution Wind Field Reanalysis over Beaufort-Chukchi Seas:  
Data Introduction and Regional Climate Change Detection**

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The Beaufort and Chukchi seas and its adjacent coastal and inland areas has experienced drastic changes across all climate system components, strikingly evidenced by an acceleration of sea ice reduction and an extreme sea ice loss in summer 2007. These changes and associated extreme events may increase threat for national energy security and environment, given potential infrastructure destruction and oil spills. It is therefore important to realistically capture and better understand high-resolution wind field in this area. This presentation will provide an overall introduction of our recently completed experimental reanalysis of high-resolution surface wind field from 2005-09. To create this reanalysis, we employed the state-of-the-art Weather Research and Forecasting Model (WRF) and its data assimilation system with optimized model physics and initial and boundary conditions, constrained by surface and satellite based observations we collected and quality-controlled in the study area. The WRF model and its assimilation system were configured to provide gridded surface wind as well as other meteorological data at resolutions of 10 km in space and 1 hour in time, which is crucial for resolving and better understanding high-frequency wind variability and finer-scale weather extremes, ocean eddies and boundary currents, and for making credible assessment or prediction of oil spill dispersion, ocean waves, and coastal erosions. Analysis of the new data suggests a large seasonal swinging of surface wind pattern and an increase in wind speed. Changed wind distribution and speed would increase vulnerability of sea ice for reduction in conjunction with enhanced radiative forcing by greenhouse emissions.

### **Beaufort Gyre sea ice biota at the end of summer melt**

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The ice cover of the Beaufort Sea gyre has experienced a dramatic decrease in its summer extent in the past decades. Yet, the response of the sea ice biota to enhanced summer melt is poorly studied. The present study investigated ridged and level (both old and newly formed) ice using SCUBA and ice cores, respectively. Eleven stations were sampled over the Chukchi Borderlands and southern Canada Basin at the end of the summer melt during October 2009. Mean chlorophyll a concentrations were low in all ice types, mostly <1 ug/L in the bottom 10 cm. At all locations, sea ice meiofauna concentrations were also low (mostly <20 individuals/L in the bottom 10 cm of cores and in ridge pieces) and were dominated by acoel flatworms, copepods and their nauplii and nematodes. Taxon distribution differed between ice types. Under-ice fauna, amphipods and Arctic cod, were sparse at all locations and ice types. Highest values for chl a, PON and POC and ice meiofaunal concentrations occurred in ice cores and ridge samples over the Chukchi Borderland. Chl a concentrations and meiofaunal densities were significantly more depleted in ice and water samples in the Canada Basin than the Chukchi Borderland, reflecting influence from the MacKenzie River. Three Chukchi Borderland stations had highly enriched d13C ratios in ice cores, perhaps indicating high ice-associated biomass accumulation earlier in the season.

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

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Snow crab, *Chionoecetes opilio* support an important commercial fishery in the southeastern Bering Sea and northwest Atlantic. Little is known, however, about the species' occurrence and stock characteristics in the Arctic including the Alaskan Beaufort Sea. Climate warming, resulting in possible species range extensions, and resource development in the Arctic have increased the interest in northern crab stocks. Snow crab were collected with bottom trawls in the Alaskan Beaufort Sea in Aug-Sept of 2008 and 2011 at depths of 40-322 m. Crabs ranged in size from 15-130 mm carapace width, thus including some commercial size males. Most specimens collected were males while only few were mature females carrying eggs. The broad size range of immature females suggested that maturity may occur over a wide range of body sizes. Crabs >70 mm carapace width exclusively occurred in water depths =180 m. The vast majority of crabs were classified as new shell with hardly any epigrowth. This study extends the known range of snow crab in the Alaskan Beaufort Sea eastward to 147.8 degrees W. We also collected 3 blue king crabs (2 females and 1 male) at 180 m depth, probably extending the known distribution of that species eastward to 148.8 degrees W. Additional surveys of snow and blue king crab on the Beaufort Sea slope are recommended to provide relevant stock information for the Arctic Fisheries Management Plan and for potential impacts from oil and gas exploration & development.

**Fitting snow crabs into benthic food webs in the central Alaskan Beaufort Sea**

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Global climate change and the warming of marine waters have been correlated with the northward contraction of the commercially important snow crab, *Chionoecetes opilio*. The effects of ocean warming may have significant effects on *C. opilio* population dynamics through altering population dynamics, energy requirements and possibly positioning in the food web. Though snow crabs are not currently commercially harvested in the Alaskan Arctic, increased interest in future fishing potential has accompanied their northward contraction. This ongoing study provides understanding of trophic positioning of snow crab in the central Alaskan Beaufort Sea, the eastern extent of their distribution. Nineteen stations were sampled in the central Beaufort Sea, with shallow sites ranging from 16-40 m (n=9) and deep sites at a depth of 178-220 m (n=10). Stable isotope analysis of 68 putative species representing 17 higher taxa was used to construct food webs with an emphasis on the trophic position of snow crabs. Particulate organic matter (POM) was used as the primary food source. This poster presents first results of the trophic position of these central Beaufort Sea snow crab, including 21 males and five females of various sizes.

**Temporal Trends of Benthic Fauna in the Northeastern Chukchi Sea, 2008-2010**

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An interdisciplinary study evaluated benthic communities near three proposed oil and gas exploration areas (Burger, Klondike, and Statoil) in the northeastern Chukchi Sea annually in 2008-2010. This study was sponsored by ConocoPhillips, Shell Exploration and Production Company, and Statoil USA E & P to collect biological and environmental information in these areas prior to exploration and provide data useful for permit applications and post-development comparisons. Benthic macrofauna and megafauna populations were surveyed and trends in abundance and biomass analyzed. Dominant benthic taxa exhibited temporal trends associated with oceanographic conditions that reflected climate variability. Macrofaunal abundance and the number of taxa increased with higher water temperatures and declined with colder temperatures while megafaunal responses were less clear. While trends were associated with water temperature, variations were found for both macrofauna and megafauna. Individual taxa responded to the inter-annual variability of oceanographic conditions to varying degrees, illustrating differing tolerances to a changing environment.

## Arctic - Lower Trophic Levels

### **Predicting the distribution and ecological niche of unexploited snow crab (*Chionoecetes opilio*) populations in Alaskan waters: A first open-access ensemble model**

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The snow crab (*Chionoecetes opilio*) is widely distributed on northern high-latitude continental shelves, representing a valuable commercial fishery resource. In US waters, commercial harvest currently focuses on the Bering Sea where population dynamics are well-monitored. However, few data exist for populations further north where climate trends appear to be affecting species distributions and habitat. We examined the ecological niche and population distribution of snow crabs in Alaskan waters using a GIS-based spatial modeling approach. We present the first quantitative open-access model predictions of snow-crab distribution, abundance and biomass in the Chukchi and Beaufort Seas. Multi-variate analysis of environmental drivers of distribution and community structure commonly rely on multiple linear regression methods. Our approach improves upon regression methods by exploring non-linear relationships and interactions between variables. Three machine-learning algorithms were used to evaluate relationships between snow-crab distribution and environmental parameters, including TreeNet, Random Forests, and MARS. An ensemble model was compiled from these outputs to generate consensus predictions for presence-absence, abundance and biomass of snow crabs. Each algorithm identified a suite of important predictor variables, including nutrient and chlorophyll-a concentrations in overlying waters, temperature, salinity, and annual sea-ice cover; this information may be used to develop testable hypotheses regarding the ecology of this species. This is the first such quantitative model for snow crabs, and all GIS data layers compiled for this project are freely available from the authors, upon request, for public use and improvement.

### **Arctic ice-ocean ecosystem changes in a warming climate from modeling and observations**

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The Arctic marine food web is supported by two distinct categories of primary producers, ice algae growing within and on the underside of the sea ice, and phytoplankton growing in open waters. Both habitats are changing under amplified global warming effects as shown by various observations scattered in space and time. Here we present a series of ecosystem model validations against remote sensing and in-situ observations. The global coupled ice-ocean-ecosystem model consists of the physical model POP-CICE (Parallel Ocean Program-Los Alamos Sea Ice Model) and biological model in sea ice and ocean. The modeled sea surface Chl-a was compared with remote sensing data in different seas in the pan-Arctic regions and used to investigate the changing timing of the blooms. The in-situ data include arctic cruises from 2004 to 2008. The change in nutrients, Chl-a and carbon production and their relation to physical environments were analyzed.

### **Acoustic Detection of Zooplankton in the Chukchi Sea**

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Chukchi Sea is located within the U.S. Exclusive Economic Zone, and is covered with sea ice for approximately 7 months of the year making it inaccessible to ships. Thus it is difficult to conduct research to determine how the ecosystem responds to environmental and anthropogenic forcing. As part of the BOEMRE-sponsored multidisciplinary program CHAOZ (CHukchi Acoustics, Oceanography, and Zooplankton) we are studying this high latitude ecosystem to understand how it may respond to changes in climate, and how the response affects prey availability for bowhead whales transiting through the area. In August-September 2010, we conducted shipboard measurements of hydrography and lower trophic levels (chlorophyll, net and acoustic samples for zooplankton) along multiple, cross-shelf transects. In addition, an upward looking, 8-frequency acoustic instrument (TAPS-8; Tracor Acoustic Profiling System) was attached to a mooring deployed for year-round measurements. In August 2011 we returned to the study site, repeated our cross-shelf transects, and successfully recovered the moored TAPS-8. The instrument took measurements until at least the end of May 2011 and we will present the initial processed data. Our transect results show the sound scattering was highest at the surface and at depth with a minimum in the middle of the water column during both cruises. In 2011 we observed diel vertical migration of zooplankton at the mooring site. Two instruments, a TAPS-8 and a new TAPS-6 NG (Next Generation), were deployed in close proximity to each other in 2011 and will sample under the ice during the coming year.

### **Predicting pan-arctic zooplankton abundance at the species level**

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Zooplankton data from a wide variety of sources were assembled, in order to model abundances on a pan-arctic scale. We applied a predictive ecological niche model for the Arctic Ocean using ArcGIS and the TreeNet algorithm to map the summer-time distribution and abundance of the three dominant arctic endemic copepod species (*Calanus hyperboreus*, *C. glacialis*, and *Metridia longa*) plus a Pacific species (*M. pacifica*) and an Atlantic species (*C. finmarchicus*) that are seasonally expatriated into the Arctic. For robust estimates, the copepodite abundance data were pooled across all available years and overlaid with environmental data thought to influence the abundance and distribution of zooplankton (e.g. salinity, bathymetry, water temperature, ice cover, etc). The predictive performance of the model was higher in regions with more available datapoints, while the prediction accuracy in regions with scarce data was lower, but still informative. Patterns related to distance from advective pathways, water depth, and distance from the continental shelf are observable in the predicted abundance. Such modeling allows for quantification of complex habitat relationships. We will continue our efforts concerning the data consolidation in order to examine decadal patterns in zooplankton abundance, and to explore various climate change scenarios.

Arctic - Lower Trophic Levels

**Isotopic food web comparisons of two survey sites in the northeastern Chukchi Sea**

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The benthic communities of three (Burger, Klondike, and Statoil) proposed oil and gas exploration areas have been sampled annually since 2008. This study, sponsored by ConocoPhillips, Shell Exploration and Production Company, and Statoil USA E & P, is being used to establish baseline conditions of these areas prior to exploration and provide information useful for permit applications. Sites differ in their environmental characteristics; Klondike lies in a high flow area and has substrates ranging from mud to gravel, while Burger is primarily a depositional site with muddy sediments with Statoil reflecting characteristics of both. Preliminary results suggest that there is a 1° shift in the POM d13C values between the Burger and Klondike survey sites, which appears to be reflected in the d13C signatures of the benthic epifauna and infauna of these areas. Additionally, animals and POM collected at Klondike appear to have higher d13C signature variability than Burger, possibly indicating greater variability in food source. The close proximity of the study sites will allow determination of small-scale patterns in benthic food web structure within the region.

**Mapping of a kelp bed on rocky substrate near Peard Bay, Chukchi Sea,  
using imagery from a towed video/sonar sled**

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The objective of this project was to explore, characterize, and map an uncharted rocky habitat in the Chukchi Sea. Professors Konar and Iken secured funding from NOAA's Office of Ocean Exploration, and they contracted with AquaLife Engineering to provide imaging, tracking, and mapping technology. We deployed a towed sled with realtime NTSC video and scanning sonar from the 37-LOA "Launch 1273" provided by BOEMRE/Kinnetic Labs. The sonar provided a wide imaging swath for detection of acoustic targets such as rocks, and the video provided truthing of the sonar returns. Several days of search within 5 nm of Barrow did not locate significant shallow hard substrate. Based on a literature report of kelp collected in a dredge tow from 1954 (Mohr JL, Wilimovsky NJ, Dawson EY (1957) An Arctic Alaskan kelp bed. Arctic 10:45-52), we travelled 50 nm to the SW of Barrow to the vicinity of 70 51.5N / 158 8.5W. We found an extensive area of rocky bottom there, including gravel, cobbles, boulders, and apparent bedrock. Approximately 10 hours on station were devoted to video/sonar track recordings, providing about 5 nm of bottom coverage. Video images of the substrate types and biological communities (soft coral, red algae, brown algae) are presented along with correlated sonar imagery. Preliminary habitat and substrate maps produced with HYPACK software are also shown. Professors Iken and Konar performed SCUBA quadrats, transects, and biological collections at three locations to support ecological and taxonomic/genetic studies, to be reported later.

### **Community composition of demersal marine fishes in the Canadian Beaufort Sea**

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A species assemblage analysis was conducted using data from the CCGS Nahidik Fishing program, 2006 - 2009, in the Canadian Beaufort Sea. Ordination analysis suggests the presence of shallow (50m) fish assemblages on the Mackenzie Shelf. Inter-annual variability in species composition and abundance was also observed, thus the stability of these associations is uncertain. We tested the null hypotheses that there are no differences in assemblages between: 1) stations 50 m depth, and 2) stations sampled in 2006 and 2009 at the same location. A similarity test rejected both null hypotheses at p50 m groups, and which species typified their respective groups. *Ulcina olrikii* accounted for the highest proportion of the average dissimilarity between depth groups (12.17%). For the 50 m group, *U. olrikii* was the main discriminating species (28.36%) between stations. *B. saida* also typified the >50 m group (21.49%) reflecting the ubiquitous presence of this species within the study area. These preliminary results indicate structuring within the demersal marine fish community which is likely driven by the distribution and abundances of a small subset of species, however, the temporal (seasonal and inter-annual) stability of this is uncertain.

### **Fisheries research in support of Fisheries and Oceans Canada's regulatory role in hydrocarbon development in the Canadian Beaufort Sea**

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The proposed Mackenzie Valley Pipeline Project has sparked renewed intensive oil and gas exploration in the Beaufort Sea. Governmental regulators and resource managers are tasked with assessing the impacts of multiple stressors on the region's natural environment. Proponents of development are tasked with collecting data to support Comprehensive Studies under the Canadian Environmental Assessment Act. In contrast, the federal government is mandated to provide unbiased, credible science on behalf of Canadians in order to fulfill its regulatory role. The scope of government science is to conduct regional ecosystem research and baseline data collection, in order to place individual Environmental Assessments in the context of the broader ecosystem and the cumulative impacts of multiple stressors. Fisheries and Oceans Canada's (DFO's) Northern Coastal Marine Studies program (NCMS), 2003 - 2009, was a multidisciplinary study aimed at characterizing the physical and biological nature of the Canadian Beaufort Shelf. Marine fish surveys were conducted from the Canadian Coast Guard Ship (CCGS) Nahidik to study the composition and spatial distribution of fish relative to physical and chemical habitat parameters, and to contribute to the general biological and ecological information on offshore fish populations. In 2010, DFO initiated a pilot monitoring study (ACES, Arctic Coastal Ecosystem Studies) in the newly established Tarrum Nirvutait Marine Protected Area to update baseline information and assess the feasibility of proposed indicators of ecosystem change. Herein, we provide an overview of these studies as they relate to DFO's role in conducting science to support its regulatory mandate.

**Length-weight-age relationships of demersal fishes in the Chukchi Sea**

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This study provides updated life history information for important and ecologically representative demersal fish species in the Chukchi Sea. Basic body measurements were examined from fishes that were collected using a small mesh bottom trawl during four cruises in Lease Sale 193 area. This study was supported by ConocoPhillips Company, Shell Exploration and Production Company, and Statoil USA E&P Inc. in 2009 and 2010. Length-weight relationships were calculated for 18 species of fish. Ages were estimated from otoliths of six abundant species representing five families. All the fishes were small, though not all were young. Arctic cod (Gadidae) 20-150 mm were ages 0-3. Arctic staghorn sculpin (Cottidae) 20-120 mm were ages 0-4. Shorthorn sculpin (Cottidae) 20-110 mm were ages 0-2. Polar eelpout (Zoarcidae) had the largest size range, 30-200 mm, and were ages 0-10. Stout eelblenny (Stichaeidae) 40-140 mm were also ages 0-10. Bering flounder (Pleuronectidae) 15-150 mm were ages 0-5. Ages of Arctic cod were comparable to those of this fish in other circumpolar areas. Seasonal and interannual patterns in length and age distributions were observed.

### **An Atlas of Sea Duck Blood Cells**

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The complete blood count (CBC) is an essential tool for surveying the health of an animal. A blood sample is collected and analyzed to measure components such as red blood cell volume and platelet numbers. An important portion of the CBC is measuring the white blood cell (WBC) count. If WBCs are elevated, infection may be present in the animal. Most mammalian blood can be processed through an automated CBC machine, however, that is not true for birds. Unlike mammals, avian red blood cells and platelets are nucleated causing erroneous results for all parameters when processed through such machines. Therefore, for birds, an indirect method for measuring WBCs is often utilized. Part of the protocol involves completing a differential of a blood smear to quantify the various white blood cells. Identifying all the cells in a smear properly is essential when calculating an accurate white blood cell count. This poster illustrates red blood cells, thrombocytes, heterophils, lymphocytes, monocytes, and basophils of five different sea duck species. Examples are shown for the Harlequin duck (*Histrionicus histrionicus*), Long-Tailed duck (*Clangula hyemalis*), King eider (*Somateria spectabilis*), Spectacled eider (*Somateria fisheri*), and the Steller's eider (*Polysticta stelleri*). Certain cells can look similar across avian species, but there are subtle differences that need to be recognized when performing a differential.

### **Monitoring marine birds in the nearshore Chukchi Sea: preliminary findings from the AKMAP Program in the coastal northeastern Chukchi Sea, 2010–2011**

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The Alaska Department of Environmental Conservation (ADEC) and University of Alaska School of Fisheries and Ocean Sciences, Fairbanks (SFOS), established an Alaska Monitoring and Assessment Program (AKMAP) that is focused on monitoring the status of aquatic resources in Alaska's waters. In 2010-2011, we surveyed for marine birds as the vessel transited between oceanographic stations in nearshore waters of the Chukchi Sea between Point Lay and Barrow. We assessed the current distribution, abundance, and species-composition of the marine-bird community in relation to environmental characteristics such as water depth, halocline depth, sea-surface temperature, and distance to nesting colonies. We also compared current and historical species-composition of the bird community based on data provided by the North Pacific Pelagic Seabird database. During this study, we identified several relationships between seabirds and oceanographic characteristics that may be valuable in predicting marine-bird community composition in relation to oceanographic changes. We also have detected a change in species-composition of the marine-bird community in the nearshore Chukchi Sea that parallels shifts in species-composition seen elsewhere in the Chukchi Sea and that presumably reflects large-scale changes to the ecosystem.

**Seals and Walrus Distribution in the offshore northeastern Chukchi Sea:  
Relation with Potential Prey Organisms**

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One objective of the interdisciplinary Chukchi Sea Environmental Studies Program, sponsored by ConocoPhillips, Shell, and Statoil, was to collect data on the abundance and distribution of marine mammals in and near three proposed oil and gas prospects in the offshore northeastern Chukchi Sea (Klondike, Burger and Statoil study areas). Vessel-based marine mammal data were collected during July-October of 2008-2010 along line transects. During 17,781 km and 1,161 hours of on-transect effort in the study areas, 881 seals and 194 walrus were sighted. Densities were calculated using species-specific detection functions, corrected for parameters that affect probability of detection. Average densities per year and area ranged from 0 to 0.126 ind/km<sup>2</sup> for ringed seals, 0.006 to 0.036 ind/km<sup>2</sup> for spotted seals, 0.004 to 0.070 ind/km<sup>2</sup> for bearded seals, and 0.004 to 0.036 ind/km<sup>2</sup> for walrus. Although there was a high interannual variability in abundance of seals and walrus that partly reflected different ice conditions, the data suggest that benthic-feeding bearded seals and walrus generally were more common in the Burger and Statoil study areas, which are benthic-dominated ecosystems. Pelagic-feeding spotted seal species tended to be more common in the Klondike study area, which is a more pelagic-dominated system. Ringed seals did not show a clear preference. In conclusion, the different oceanographic conditions of the three study areas seem to affect the distribution of some pinnipeds more than others.

**Seasonal migration of bearded seals between intensive foraging patches**

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Bearded seals (*Erignathus barbatus*) are one of the most important nutritional and cultural resources for northern Alaska coastal communities. They may be at risk from loss of, or shifts in their sea-ice breeding habitat, and from other ecological consequences of climate warming. Six bearded seals tagged with satellite-linked geo-locators and dive recorders in Kotzebue Sound undertook rapid northward migrations to the Chukchi and Beaufort Seas during July as the sea ice receded, and southward migrations to the Bering Sea as the ice advanced during autumn. Between these directed seasonal movements, a large portion of the seals' time was spent in small areas, foraging intensively as indicated by the frequency of dives and the limited scope of movements. Some individuals returned to the same or nearly the same winter foraging patches they had used in the previous year. These spatial characteristics of bearded seal foraging patterns, while not unexpected for a predominantly-benthic forager, may have implications for individuals' <sup>TM</sup> resilience to shifting ice distributions in response to climate warming and to impacts from industrial activities.

**Ice, seismic activity and the 2010 fall migration of bowheads through Harrison Bay  
in the central Beaufort Sea**

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Sea ice distribution and offshore human activities may both influence the location, relative to shore, of the fall bowhead whale migration corridor through the central Beaufort Sea. Given oil and gas exploration interest in the area and the importance of the annual subsistence bowhead hunt to local villages, there is a need to understand the relative influence of these factors on bowhead migration. During 2010, Shell conducted shallow hazard seismic surveys in Harrison Bay. During that time, aerial surveys and bottom-mounted acoustic recorders collected data on bowhead distribution. Aerial sightings of bowheads during seismic activity were farther to the south, and closer to the seismic survey area, than during non-seismic periods. This shift appeared related to intra-annual changes in the distribution of sea ice in the study area. While inference from visual sightings may be confounded if sighting probabilities are related to the extent of ice-covered water, an investigation of acoustic detections was found to exhibit a similar spatial pattern with respect to ice. To illustrate the relationship between ice and the 2010 fall migratory path through Harrison Bay, maps were produced which overlaid aerial sightings, acoustic call detections, and ice concentrations through time. The maps show that the migration was deflected north around higher concentrations of ice in the early season, and then shifted south when the ice dissipated. Together, these independent data sources suggest that ice (or related environmental conditions) had a greater impact than seismic activity on the 2010 fall bowhead migratory path through Harrison Bay.

**Eastern North Pacific Gray Whales and Minke Whales from Aerial Surveys in the Alaskan Arctic, Summer and Fall 2011**

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Aerial surveys were conducted in the northeastern Chukchi Sea in 2011 from mid-June to late October, as part of the Aerial Surveys for Arctic Marine Mammals project funded by the Bureau of Ocean Energy Management. The study area covered 157°W to 169°W and 68°N to 72°N. Surveys were flown in a Twin Turbine Aero Commander. Gray whales were sighted nearshore between Point Barrow and Point Lay, and offshore of Point Hope, both locations where gray whales have been observed in high densities historically (1982-1991) and in recent years (2008-2010). As in recent years, few gray whales were sighted near Hanna Shoal in 2011, an area of high densities in historical years. Gray whale calves, not observed in every year, were frequently sighted, particularly during the months of June and July. Several minke whales were sighted in both nearshore and offshore areas, including one sighting that may be the furthest north documented to date. Prior to 2011, minke whales had not been documented north of Point Hope by these aerial surveys, although they have been detected by passive acoustics and reported by industry-sponsored marine mammal observers, U.S. Fish and Wildlife Service and other sources in the Chukchi Sea. Results from these surveys indicate that the northeastern Chukchi Sea remains an important habitat and feeding ground for the Eastern North Pacific stock of gray whales; furthermore, there is increasing evidence that minke whales may be expanding their range north.

### **How Well Do Stable Isotopes Represent Bearded Seal Diet?**

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A common way to study animal diet is the analysis of stable isotope ratios in tissues. Stable isotopes represent a mixture of prey consumed over a tissue-specific timeframe. Isotope data can be used to detect large scale changes in prey consumption, but has limited taxonomic resolution. Mixing models have been developed to increase the resolution of data, but are restricted in the number of prey categories that can be included in the analysis. To quantify these limitations, we analyzed stable isotope ratios in muscle of 36 bearded seals (*Erignathus barbatus*), a benthic generalist, and used a mixing model (SIAR) to estimate diet. The Alaska Department of Fish and Game analyzed stomach contents from 298 bearded seals, including the animals examined for stable isotope ratios, and identified 168 different prey taxa. Due to mixing model restrictions, incomplete isotopic prey libraries, and overlapping prey isotope signatures, prey data used in the mixing model had to be consolidated into 5 trophic groups. Each trophic group included multiple prey taxa representing approximately 85% of the total prey items. Isotope mixing model results overestimated pelagic fishes in the diet (45%) compared to relative occurrence from stomach contents (19%), and similarly overestimated crabs/flatfishes (34% vs. 24%). In contrast, mixing models underestimated shrimp/whelk/benthic fishes (14%) compared to relative occurrence from stomach contents (34%). In addition to underrepresenting the number of prey taxa, the mixing model both over and underestimated the proportions of major prey groups found in stomach contents of bearded seals.

### **A Drill in Time: Stable Isotope Analysis of Ice-Seal Claws**

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The Arctic is changing rapidly as sea ice thickness and extent decreases. In response to continued sea ice habitat loss and reduced snow cover, bearded (*Erignathus barbatus*) and ringed seals (*Pusa hispida*) are proposed to be listed as threatened under the Endangered Species Act. Climate change and sea ice reduction may have other, more subtle effects, such as changes in primary production that propagate to higher trophic levels. Many studies have used stable carbon and nitrogen isotope ratios in baleen, whiskers, and other keratinized structures to assess long-term feeding records. We examined the dietary history recorded in claws of bearded and ringed seals to document potential seasonal and interannual changes in their foraging. Seasonal keratin layers deposited in claws can document diet up to about 10 years. Sixteen claws for each species were collected during Alaska Native subsistence harvests in 2008, 2009, and 2010 and seasonal growth bands were analyzed for stable isotope ratios. Results indicate carbon and nitrogen isotope ratios of bearded seal claw growth layers are less variable than those of ringed seals over time. While no general patterns emerged for all analyzed seals, in 2007 proportionally more ringed seal individuals fed at a trophic level lower than normalized values. Ice seals in the Alaskan Arctic are highly adaptable to changes in food web structure making them likely more resilient to the effects of climate change on trophic dynamics.

**Aerial Observations of Pacific Walruses (*Odobenus rosmarus divergens*) in the Northeastern Chukchi Sea, Summer and Fall 2011**

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In summer and fall 2011, marine mammal aerial surveys were conducted in the northeastern Chukchi Sea, as part of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project funded by the Bureau of Ocean Energy Management, Regulation and Enforcement. Surveys were conducted from mid June to late October, and encompassed the northeastern Chukchi Sea from 68°N to 72°N, between 157°W and 169°W. Pacific walruses (*Odobenus rosmarus divergens*) were distributed throughout the survey area and were observed in all months of the study period. In June and July, when sea ice was still present in the study area, walruses were either hauled out on ice or swimming in open water. In early August, when sea ice had receded north and the study area was virtually ice-free, walruses were observed only in open water and were starting to congregate nearshore. By mid August, the first aggregation of walruses hauled out on the Alaskan coastline was observed. The aggregation was located approximately 3 nmi northeast of Point Lay, Alaska, relatively close to where walrus haulouts were documented during aerial surveys conducted in 2010. The haulout was observed on subsequent surveys near Point Lay, with group size estimates varying among surveys. In 2011, walrus aggregations on land were observed earlier and for a longer period of time compared to coastal haulouts that were observed in 2009 or 2010.

**Seasonal variation of ringed seal (*Phoca hispida*) calls in the Chukchi Sea, north of Pt. Barrow from 2008 to 2009**

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Ringed seals (*Phoca hispida*) are found year-round in Arctic waters and are closely associated with sea ice. To determine the seasonality of ringed seal vocalizations, we analyzed long-term acoustic recordings collected from September, 2008 to June, 2009 at a site 120 km north of Barrow, Alaska. We present a repertoire of ringed seal calls detected at the study site. The calls can be categorized into three main types: barks, yelps, and growls. Barks and yelps are further divided into five and two sub-types respectively. We determined the seasonal variation in occurrence of each call type. Regular barks are found throughout the winter and spring while undulating barks occur mostly in winter. Downswept yelps occur throughout the winter and spring, while other types of yelps occur more often in the spring. Growls occur most commonly in winter and are not found past April. . These results suggest that ringed seals may change their acoustic behavior based on environmental and life history factors, such as sea ice cover and mating.

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**Distribution and Relative Abundance of Belugas (*Delphinapterus leucas*) in the Alaskan Arctic, Summer and Fall, 2011**

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Aerial surveys for marine mammals were conducted in the northeastern Chukchi Sea and Alaskan Beaufort Sea from mid-June through late October 2011, under the auspices of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). The study area encompassed approximately 230,000 km<sup>2</sup>, extending from 140°W to 169°W and 68°N to 72°N. A Twin Turbine Aero Commander aircraft with 5.5 hour flight endurance and a de Havilland Twin Otter aircraft with 4.0 hour flight endurance were used for these surveys, allowing for safe and effective survey coverage. Line-transect surveys were flown every day, weather and logistics permitting. Survey effort in 2011 surpassed efforts in previous years, with >50,000 km flown (not including deadhead or unusable effort), including ~40,000 kilometers on transect. There was essentially no ice in the study area in late summer and fall, as sea ice receded to conditions similar to those seen each year since 2007. Belugas were seen in all months, with the lowest numbers observed in August. Sightings were distributed throughout the northeastern Chukchi Sea, while distribution and habitat preference in the Alaskan Beaufort Sea heavily favored the continental slope and Barrow Canyon. Beluga distribution patterns and habitat preference were similar to those seen in 2007-2010, but relative abundance was higher in 2011.

**Short-term trends in the summer distribution of cetaceans in the Chukchi Sea**

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The combination of visual observations and passive acoustic monitoring is extremely useful for evaluating the short-term distribution and movements of marine mammals. These visual-acoustic surveys complement data obtained by long-term moored recorders by allowing for a larger coverage area. Daytime visual observations and near-24 hour passive acoustic monitoring (sonobuoys) were carried out for the CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton study) field efforts which operates in the area between Nome and Barrow, AK. During the 2010 cruise (24 Aug - 20 Sept, 2010), a total of 1,478 miles were visually observed, and 102 sonobuoys were deployed. Results from the visual observations include a total of 53 sightings (69 individuals) of 7 confirmed cetacean species, 8 walrus sightings (23 individuals), as well as an additional 17 sightings (18 individuals) of unidentified cetaceans. The most common species acoustically detected were bowhead and fin whales, and walrus. However, the most common acoustic detections were seismic airguns, detected on over 37% of the buoys (38 of 102). During the 2011 CHAOZ cruise (12 Aug - 11 Sept, 2011), 104 sonobuoys were deployed and 816 nm were visually surveyed. Visual results include a total of 92 sightings (139 individuals) of 8 confirmed marine mammal species as well as 48 sightings (51 individuals) of unidentified marine mammals. Most common acoustically detected species include walrus, fin and gray whale, though seismic airguns again were the most common detections. [Work supported by the Bureau of Ocean Energy Management, Regulation, and Enforcement]

### **Results from village-based walrus studies in Alaska, 2011**

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Pacific walrus 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 walrus 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 walrus land haulouts. During fall 2011, a large haulout (20-25,000 walrus) formed near the village of Point Lay where residents minimized disturbances to the haulout by directing boat traffic and other potential human disturbances. Large haulouts are susceptible to stampedes, which can cause calf mortalities. Local hunters also documented the number and condition of carcasses near the haulout and, in doing so, observed skin lesions on several dead walrus. Samples were collected from potentially infected walrus for analysis. During spring 2011, efforts to tag walrus near Wales and Point Hope were unsuccessful due to unfavorable sea ice and weather conditions. We met with elders and walrus hunters in Wainwright and Point Lay to document historical terrestrial haulouts and walrus behavior. Future plans include deploying tags with local hunters near Little Diomed and meeting with elders at Barrow and Point Hope.

### **Polar Bear Recovery Planning: Reconciling Endangered Species Act Requirements with the Reality of a Rapidly Melting Arctic**

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The polar bear was listed as "threatened" under the Endangered Species Act (ESA) in May 2008 due to the ongoing and projected loss of its sea-ice habitat, becoming the first species listed under the ESA solely due to the threats posed by global warming. The listing of a species under the ESA imposes both affirmative and prohibitory mandates upon the U.S. Fish and Wildlife Service (FWS) and other federal agencies, including requirements to designate critical habitat and to develop and implement a recovery plan, and prohibitions against actions that "adversely modify" critical habitat or "jeopardize" the species. While virtually all aspects of polar bear management post-listing have triggered controversy, recovery planning for the species presents particular challenges. The ESA requires recovery plans to include "objective, measurable criteria" for delisting, as well as estimates of the time and cost needed to achieve the plan's recovery goals. Recovery of the polar bear is impossible absent rapid reductions in greenhouse gas emissions and consequent lowering of atmospheric carbon dioxide levels. As such, any recovery plan for the polar bear that meets statutory standards must address greenhouse gas reductions. In this presentation we discuss the ESA's recovery planning requirements and the challenges related to applying these statutory mandates to the polar bear. We then outline a path forward in which a polar bear recovery plan can serve as a useful tool to address the primary threat facing the species.

**Will global warming result in habitat gains for ice-breeding bearded seals?**

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Global warming has dramatically reduced Arctic sea ice during the past several decades and is predicted to do so at an increasing rate in the future. Ice-breeding phocids such as bearded seals (*Erignathus barbatus*) rely on sea ice as a safe, dry platform for whelping and rearing their pups during spring, and molting their coats during early summer. Loss of sea-ice habitat during this critical period could have serious impacts on their recruitment and health. Based on limited data documenting bearded seals' preferred ice concentrations and foraging depths, we analyzed climate model projections of monthly (April-June) sea-ice concentrations averaged over the decades centered on 2010 and 2090 to predict habitat changes for each of the species' three populations. From 2010 to 2090, predicted net changes in habitat area ranged between -36% and -100% for the Okhotsk population, -23% and +26% for the Beringia population, and +50% and -21% for the *E. b. barbatus* population. These results beg the question of whether global warming will be uniformly negative for bearded seals as a species. The answer will depend upon whether bearded seals are able to make use of potential "habitat gains" (i.e., areas of shallow water currently considered unsuitable due to very dense ice concentrations that are projected to break up earlier in the melt season by 2090). Additional monitoring of bearded seals' current habitat preferences will be required to increase our confidence in discerning the species' ability to adapt to a rapidly changing environment.

**Acoustic detections of bowhead whales in the northeastern Chukchi Sea, September 2007 to July 2011**

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A passive acoustic monitoring program sponsored by Shell Exploration and Production Company, ConocoPhillips and Statoil USA has been in place in the northeastern Chukchi Sea (CS) since July 2006 to monitor natural and anthropogenic ambient sound levels and to survey marine mammals. Bowhead whales are targeted by this program as increasing oil and gas exploration activities occur within their migration pathways. Here we report on bowhead acoustic detections from September 2007 to July 2011. The results are based on the manual review of 5% of the acoustic data combined with automatic processing (using an auto-detector) of the entire dataset. These analyses produced estimated call counts for each station, from which bowheads' relative abundance throughout the study area was inferred. Spring detections started as early as March 30 but the core of the migration took place from mid-April until mid-June. Late migrants were sporadically detected until late July. Detections at offshore locations (>90km offshore) indicate that part of the population migrates outside the lead that forms inshore between Cape Lisburne and Barrow and is considered the typical spring route. Call detections in August were rare. The fall migration started in September and peaked in October and November. Bowhead detections continued as late as December 31. Ice conditions seem to influence the timing of bowheads' departure from the CS. Call count surface plots suggest that most whales migrate west from Barrow near 71.5°N, though others follow the coast until Wainwright or Point Lay before turning west.

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**Bowhead Whale (*Balaena mysticetus*) Distribution and Relative Abundance  
in the Alaskan Arctic, Summer and Autumn, 2011**

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Aerial surveys for marine mammals were conducted in the western Beaufort and northeastern Chukchi Seas from mid-June to late October, 2011, as part of the Aerial Surveys for Arctic Marine Mammals project, funded by the Bureau of Ocean Energy Management, Regulation and Enforcement. The study area for these line-transect surveys ranged from 140-169oW and 68-72oN, extending from the coast out to approximately 315 km offshore. The surveys were conducted in Twin Turbine Aero Commander aircraft with 5.5 hour flight endurance and a de Havilland Twin Otter with 4 hours of endurance. The 2011 surveys covered over 50,000 km of effort (excluding transits over land and in poor visibility), including over 40,000 km on transect, exceeding effort achieved in previous years. Bowhead whales were sighted during every month, including 2 sightings near leased blocks in the Chukchi Sea Planning Area on 19 June. In addition, 18 bowhead whales, including milling and feeding animals (one with a muddy rostrum), were sighted on 14 July in a region north of Camden Bay, near the last known position of a satellite tagged bowhead whale. The westward autumn migration across the western Beaufort Sea began relatively late in 2011 compared to the previous three decades. These surveys continue to provide broad-scale information about the distribution, relative abundance, and behavior of bowhead whales and other marine mammals in regions of renewed interest to the oil and gas industry in the Alaskan Arctic.

### **Mortality of Walruses at a Coastal Haulout, Point Lay, Alaska, Autumn 2011**

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In the fall of 2011, a large (15,000 - 20,000) herd of Pacific walruses (*Odobenus rosmarus divergens*) hauled out onto a barrier island near the coastal community of Point Lay, Alaska. A total of 28 walrus carcasses were encountered during a 25 mile coastal survey (September 11-15) of the area. True mortality may have been higher as high surf preceding the survey period likely swept carcasses away. Gross findings included several specimens with signs of trauma (e.g. crushed bodies, hemorrhages, epistaxis) suggestive of trampling associated mortality. Several carcasses also had disseminated circular ulcerative skin lesions on their head, neck and torso. The underlying etiology of the observed skin lesions is unknown. We collected viral and bacterial swabs from 4 fresh carcasses and did a necropsy on a 5th animal. The disease investigation is ongoing and further results are pending. Approximately 6% of the living animals observed at the Point Lay haulout site appeared to be afflicted with the observed skin condition, with an age distribution of 65% sub-adults, 35% adults. Live animals with skin lesions generally appeared otherwise healthy and robust. Calves and yearling animals were poorly represented in the living herd although these age classes were prominent among the surveyed carcasses. It is unknown whether the skewed age distribution is an indication of a high mortality levels among younger age classes due to trampling and/or disease, or reflects the specific herd demographics of the Point Lay haul out site.

### **Interannual Temporal and Spatial Distribution of Bowhead Whales in the Western Alaskan Beaufort Sea; 2007-2010**

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To minimize potential impacts from petroleum development activities in the Beaufort and Chukchi Seas, an increased understanding of bowhead behavior and distribution is needed. Year-round passive acoustic monitoring began offshore of Barrow in 2007 as part of the interdisciplinary BOWFEST (Bowhead Feeding Ecology Study) project. The study area spans from the northern coast of Alaska out to 72°N and between 152°-157°W. To better understand how bowhead whales use this area, both long and short-term autonomous passive acoustic recorders were deployed on subsurface moorings. The long-term moorings were deployed at four locations along the 100m isobath off Barrow, running on a 30-45% duty cycle at a sampling rate of 8192Hz. The short-term recorders were deployed inshore and sampled at either 12.5 or 40kHz on an 80-90% duty cycle (although one sampled continuously at 8192Hz). Since 2007 we have obtained 18,820hrs of recordings from the long-term (2107 deployment days) and 3780hrs of recordings from the short-term (178 deployment days) moorings. Recordings were reviewed manually, with the long-term data analyzed on a three-hour time interval and short-term data analyzed fully. In all years bowheads used the area off Barrow until late November /early December. Whales returned to the area with the spring migration in early April. Very few bowhead detections were made during the winter months. In 2009 and 2010 bowheads were detected throughout the summer on the long-term moorings. [Work supported by BOEMRE/DOC]

**Preliminary Result on the Spatial Distribution and Clinical Presentation of an Emerging Disease Syndrome in Ringed seals of the Arctic Ocean**

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Starting in July 2011, sick ringed seals (*Phoca hispida*), of all age classes were observed to haul out on Barrow beaches. The preliminary number of stranded cases is 107. Additional observational data (villages, hunters) indicates similar scenarios along the North Slope Borough coastline (n=142+), Canada North West Territories, and the Russian Chukchi. Dedicated regular beach surveys (Barrow) were implemented and carcass/live animal surveys conducted. In collaboration with the Alaska Marine Stranding Group and National Marine Fisheries Service, carcasses and live animals were examined and samples collected. Body condition in affected seals ranged between poor and average. Seals appeared lethargic/depressed and were easily approached. Labored breathing, in conjunction with elevated respiratory rate was noted. Delayed molting, patchy to complete hair loss, and raised vesicles were common across the body. Ulcerated crater like circular skin lesions (0.5 -1 cm) were common on the hind flippers, peri-ocular, at the base of the tail, and axillary region. Fresh lesions oozed blood. Ringed seals are primarily affected, however a similar skin condition has been observed in bearded seals (*Erignathus barbatus*, n=2) and in several dead walrus (*Odobenus rosmarus divergens*) near Point Lay. To better understand behavior and the mortality associated with the disease syndrome a limited number of ringed seals (affected & clinically healthy) have been tagged in Barrow. At this time the underlying etiology is unknown. The disease investigation is ongoing and further results are pending.

**Movement and haulout behavior of ringed seals during the 2011 open water season**

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Twenty ringed seals (*Phoca hispida*) of all age classes were satellite tracked with the Argos system between July and November 2011. Seals were tagged near Barrow, AK using a combination of head-mounted (SPLASH) and flipper-mounted (SPOT) tags. SPLASH tags provided locations of seals in the water, as well as dive, temperature, and haulout data. SPLASH tags were glued to the hair and will be shed during the annual molt. SPOT tags were mounted to last more than a year but only provide location and haulout information when seals are out of the water. Locations were derived using the new Argos Kalman filtering method. Retention of SPLASH tags was lower than expected likely due to an unidentified disease that caused hair loss beyond the normal molt period. Several tagged seals made extensive roundtrip movements between the Alaska coast and the southernmost ice edge, with some seals traveling more than 400 km north of Point Barrow. One individual traveled more than 724 km east to Mackenzie Bay, Canada in the southeastern Beaufort Sea. Foraging type movements occurred both over the continental shelf and over the deep waters of the Arctic Basin. Seals hauled out periodically throughout the open water season either on shore or on the pack ice.

### **Bowhead whale feeding efficiency – Making a living in the Arctic**

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Bowhead whales (*Balaena mysticetus*) are a subsistence resource of cultural significance to Arctic Native communities. Prey density is of paramount importance to filter feeding cetaceans to maintain energy balance, yet little is known about bowhead metabolic demands and digestive efficiency of their common zooplankton prey. Samples of fresh euphausiids and digestive contents were taken along the alimentary tract of subsistence-harvested bowheads during fall 2009 and 2010 from forestomach, fundic and pyloric chambers, duodenum, and colon (n=10). We used proximate analyzes (%water, %lipid, %protein, %ash) and bomb calorimetry to assess changes in energy density and composition of digesta. Digestive efficiencies were calculated based on "start" composition of euphausiids to "end" composition of colon contents. Protein digestion occurred in the forestomach, consistent with chitinolytic, microbial fermentation leading to lipid release from prey. Efficiency of bowhead protein digestion was ~90%. Lipids were not taken up until the duodenum with an efficiency of ~50%. Due to the high caloric density of lipids, this trend was repeated in total caloric contents of different stomach compartments and dropped from 22.4kJ/g in euphausiids to 10.8kJ/g in colon contents. Using respiratory frequency of whales tagged near Barrow in 2009 and 2010 and lung volume estimates, we determined field metabolic rate (MR) of feeding adults (~9m length) as ~20kW. MR estimates for migrating whales were ~7kW (1.7x Kleiber). Preliminary estimates indicate that feeding whales may expend as much energy acquiring food as is gained and suggests tradeoffs between prey intake and digestibility.

### **Walrus Foraging Areas in the Chukchi Sea during Years of Scarce Summer Sea Ice**

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The Pacific walrus feeds on benthic invertebrates in shallow waters and rests upon sea ice between foraging trips. The lack of sea ice in the Chukchi Sea in recent summers has prompted changes in habitat utilization by female and young walruses, including recent use of coastal resting grounds. Identifying key walrus foraging areas is urgently important, because climate models project continued losses of sea ice in the Arctic, which is likely to reduce the extent of offshore resting platforms available to walruses and lead to increased human activities in walrus habitats. We estimated kernel densities of walrus foraging from telemetry data collected in years when walruses responded to summer sea ice scarcity (2008-2011). In U.S. waters, we identified a large foraging area near Hanna Shoal, an area of high organic deposition and benthic productivity, which was apparently utilized by walruses in past decades. Adjacent to a newly formed haul-out on the northwestern coast of Alaska, we identified a smaller foraging area, which did not correspond to high benthic biomass. In Russian waters, we identified a large foraging area off the northeastern Chukotkan coast. Other foraging areas likely occur in waters north of Chukotka, but are poorly defined because of insufficient telemetry data. In general, areas of high foraging in the Chukchi Sea corresponded to areas of reported high benthic biomass. With future reductions in summer sea ice, it will be important to monitor potential changes to patterns of walrus habitat utilization.

Arctic - Mammals

**Do bowhead whales avoid sound pressure levels of 120 dB re 1 $\mu$ Pa (rms) from seismic surveys during fall migration?**

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Bowhead whales are known to deflect away from industrial operations that emit sound into the water. Some evidence indicates that deflection of some whales may begin at sound pressure levels (SPLs) as low as 120 dB re 1 $\mu$ Pa (rms). This has led to concerns that if whales moved farther offshore during the fall migration it could adversely affect aboriginal whaling along the Alaskan Beaufort Sea coast. During 2007, 2008 and 2010, aerial surveys were flown as part of monitoring efforts in conjunction with seismic surveys in the central Alaskan Beaufort Sea. Bowhead sighting locations from the aerial surveys were analyzed with respect to seismic activity. The bearing and distance from each sighting was calculated relative to the most recent location of the survey ship during periods of seismic activity or, during non-seismic periods, relative to the center of the survey area. These standardized sighting locations were mapped on a Cartesian coordinate system showing the areas defined by the 120 and 160 dB sound radii, and provided a representative depiction of bowhead distribution relative to seismic SPLs. The resulting patterns of visual detections indicated avoidance of seismic activity by bowhead whales at distances of ~10-15 km, which was equivalent to received SPLs of 150-160 dB. There did not, however, appear to be any consistent pattern in whale distribution (e.g., animals were not always farther offshore) or other evidence of general avoidance at received SPLs of 150-120 dB. In other words, whales moved into and through areas exposed to these SPLs.

**Pacific Walrus (*Odobenus rosmarus divergens*) Abundance and Use of the Northeast Chukchi Sea Based on COMIDA Aerial Surveys**

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The National Marine Mammal Laboratory, in conjunction with the Bureau of Ocean Energy Management, Regulation and Enforcement (formerly the Minerals Management Service), has conducted aerial surveys of the northeastern Chukchi Sea as part of the Chukchi Offshore Monitoring in Drilling Area (COMIDA) project. This survey was designed to document the distribution and abundance of marine mammals during the ice-free months in potential oil and gas exploration, development and production areas. Pacific walrus (*Odobenus rosmarus divergens*) occur throughout the Chukchi Sea Planning Area, which has been surveyed since 2008, with most effort occurring in 2009-2010. We used a distance sampling approach for line transect survey data to determine abundance and trend in walrus use of the 193 lease sale area in the northeast Chukchi Sea. In a preliminary analysis of data from 2009 and 2010 we found that abundance of walrus during 2010 was approximately 30% higher than in 2009, likely owing to a large haulout that formed near Point Lay, Alaska. Additionally we have historical data that we will analyze to examine how trends have changed with respect to walrus use of the 193 lease sale area and how this may influence management decisions about resource development in this region.

**Correlating Shifting Baselines in the Arctic to Long-Term Bowhead Whale Isotope Records**

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Long-term marine mammal stable isotope records present a retrospective glimpse at historic conditions, and provide a baseline from which to judge recent changes in the environment and associated impacts on the ecology of higher consumers. We assessed geochemical changes in the Arctic ecosystem via long-term trends in carbon ( $\delta^{13}\text{C}$ ) and nitrogen ( $\delta^{15}\text{N}$ ) stable isotope ratios of baleen plates from zooplanktivorous bowhead whales (*Balaena mysticetus*), and compared these data to environmental variability in the Arctic and Bering Sea ecosystems. Incremental carbon and nitrogen stable isotope samples were collected from the baleen plates of bowhead whales harvested during subsistence hunts off of the North Slope of Alaska from 2004-2010. These data were added to an existing archive of bowhead whale baleen stable isotope ratios (from 1974-2003) to examine long-term biogeochemical trends. This study performs novel hypothesis testing using atmospheric (carbon dioxide concentrations), oceanic (sea surface temperature and sea ice index), and climatological (El Niño Southern Oscillation and Pacific Decadal Oscillation indexes) data from the North Pacific and Arctic regions to highlight the sources of the observed long-term isotopic decrease and inter-annual variability in these multi-decadal carbon and nitrogen bowhead whale stable isotope records. The comparison between biological and physical datasets facilitates the description of the linkages between environmental conditions and bowhead whale ecology, thus using a top predator to monitor the rapidly changing Arctic ecosystem.

### **Pacific Walrus and Climate Change: Observations and Predictions**

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Pacific walrus (*Odobenus rosmarus divergens*) sea ice habitats are diminishing resulting in altered walrus behavior and distribution, changes in ecosystems, and expanding commercial activities. We document changes that have occurred over several decades and make predictions to 2099. Sea ice projections result in more ice free summers of longer duration. Several stressors were identified that are directly influenced by, or interact with, sea ice changes. How these stressors materialized under three scenarios resulted in four comprehensive working hypotheses that can prioritize management and research programs, identify mitigation actions appropriate for all scenarios, and guide monitoring. In the short-term, the most plausible hypotheses predict a continuing northward shift in walrus distribution, increasing use of coastal haulouts in summer and fall, and a population reduction set by the carrying capacity of the near shore environment and sea ice refugia. Alternatively, the population continues to decline to a level where the probability of extinction is high. In the long-term, walrus may abandon the Bering and Chukchi Seas for sea ice refugia to the northwest and northeast, and ocean acidification and warming may alter walrus food resources. However, conditions that reverse current trends cannot be ruled out in the long-term. Which comes to fruition depends on how the stressors develop and the success of mitigation measures. Some scenarios indicate that successful mitigation of harvest impacts and haulout mortalities can be effective. Management and research should focus on monitoring, elucidating effects, and mitigation; while ultimately, reductions in greenhouse gas emissions are needed.

### **Year-round passive acoustic monitoring of bearded seal vocalizations at three locations in the Beaufort Sea, 2008-2010**

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Bearded seals (*Erignathus barbatus*) are a pan-Arctic species that are relatively abundant and widely distributed in the high north. In the Beaufort Sea, they occur mostly on pack ice, migrating with the annual advance and retreat of the ice front. These highly vocal seals are known for their long, loud trills, produced primarily in the spring and believed to be a male reproductive display. Passive acoustic data were collected for two consecutive years from September 2008 - 2010 at 3 locations 150 km apart in the western Beaufort Sea. All instruments were suspended 5 m above the sea floor and moored at 50-100 m depth. Five instruments recorded on a 30% duty cycle from 10-4096 Hz; a single instrument in 2009-10 recorded on a 20% duty cycle (10-8192 Hz bandwidth). Acoustic data were visually examined for bearded seal calls to obtain presence-absence of vocalizations. For each instrument, the number of hours per day with vocalizations was compared with in situ temperature and satellite-derived daily sea ice concentration. At all sites, bearded seals were vocally active year-round, peaking in the spring, which coincided with mating season and preceding sea ice break-up. The fewest calls were detected in August, when sea ice concentration was at its lowest, and calls increased with the formation of pack ice in the winter. A similar seasonal pattern was observed for both years, but daily call counts were lower in 2009-2010. Fall pack ice formed later in 2009 but spring sea ice concentration was similar for both years.

### **Migrations and seasonal habitats of gray whales**

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Gray whale populations recovered from depressed population numbers in the late 20th century, during a time when the development of satellite-monitored radio tagging of large whales developed into a very useful tool to discover the migrations and seasonally-favored habitats of this species. The paradigm in place during the population's recovery emphasized foraging in the Bering Sea and nearshore migrations. By tagging whales in Mexico during the 2005 reproductive season and foraging "resident" whales along the Pacific NW during the fall of 2009, it was possible to describe: 1) gray whale north and south-bound migration routes, rates and timing, including use of the spring ice lead up to Barrow and environmental correlates with movement through Bering Straits; 2) extensive use of the Chukchi Sea during summer foraging, including size and overlap of home ranges; and 3) the destination, residency time and turnover rates in the reproductive grounds. Tags transmitted for up to 11 months. Tag data provided information useful on variability in individual home ranges, core areas, migratory rates, environmental correlates, and resolving issues about genetic isolation for regional subsets of the population.

### **Results from five years of aerial surveys during the Bowhead Whale Feeding Ecology Study (BOWFEST) off Barrow, Alaska**

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BOWFEST is a five year study, which began in 2007 and focuses on bowhead whale distribution in late summer relative to oceanography and prey densities northeast of Point Barrow. Aerial surveys, boat-based surveys, and acoustic monitoring provide information on the spatial and temporal distribution of bowhead whales in the study area. Using a NOAA Twin Otter aircraft, NMML scientists conducted aerial surveys from mid-August to mid-September in 2007 (6 days), 2008 (8 d), 2009 (5 d), 2010 (8 d), and 2011 (10 d) in order to document the patterns and variability in the timing and locations of bowhead whales. Aerial photography also provides information on residence times, sizes of whales, and evidence of feeding. During these surveys, there were a total of 221 bowhead whale sightings of 707 animals, not accounting for resightings. In half of the 2007 sightings bowheads appeared to be feeding; however, aerial observers recognized feeding activity during only 4 bowhead sightings in 2008 (7%), 5 sightings in 2009 (17%), 18 sightings in 2010 (18%), and 2 sightings (11%) in 2011. "Traveling" was the most commonly recorded behavior (45% of sightings 2007-2011), indicating that bowheads were likely migrating through the study area. Results of this research program may help explain the increased occurrence of bowheads in the western Beaufort Sea in summer, well west of their typical summer range in the eastern Beaufort Sea. This information on bowhead ecology provides a foundation for assessing potential impact of industrial development in the Arctic.

**Seasonal presence and acoustic behavior of beluga whales (*Delphinapterus leucas*) north of Point Barrow, Alaska**

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Little is known about the migration routes and habitat usage of beluga whales (*Delphinapterus leucas*) in the Beaufort and Chukchi Seas. Acoustic recordings were collected north of Point Barrow, Alaska along the continental slope, from September through June of 2006 through 2010, and studied to determine seasonal presence and call characteristics of beluga whales. Beluga sounds include: whistles, clicks, and burst pulse calls. We present an analysis of whistle characteristics from key call parameters. Whistles had an average starting frequency of 2.3 kHz ( $\pm$  1.0 kHz) and were variable in duration, degree of modulation and rate of frequency change. We found three major seasonal pulses of acoustic detections, with the first being late winter, the second in mid-to-late spring, and the third in the fall. These findings help us understand when these animals utilize waters along the continental slope and give new insight into their acoustic behavior in the Alaskan Arctic.

**Estimating the age composition of Pacific walrus herds on shore haul-outs from gyro-stabilized, high definition videography**

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Female Pacific walrus stay with the sea ice as it recedes into the Chukchi Sea each summer. Walrus must rest between foraging trips, and females prefer to rest on sea ice floating directly over their continental shelf foraging habitats. Recently, the extent of Chukchi Sea summer sea ice has decreased, prompting females and their young to rest on shore, which is energetically costly, and exposes dependent calves to onshore mortality. To monitor walrus demographic rates, we are developing a method to estimate the age composition of walrus gathered at coastal haul-outs. In September 2010, we used an airborne high-resolution camera system equipped with a gyro-stabilized telephoto lens to obtain video images of hauled-out walrus herds from an altitude of 4000'. This system allowed us to operate sufficiently far from resting walrus to preclude disturbance. From this imagery, we estimated the age composition of walrus by identifying individuals to one of three age categories: dependent young = 0-2 years, juveniles = 3-5 years, and adults = >6 years. Preliminary analysis revealed that a 2.4 (CI = 1.9 to 3.0) fold greater proportion of females with dependent young were identified on shore than had been reported from offshore age composition studies. These results suggest that females with young disproportionately utilize coastal haul-outs, or that their arrival onshore is earlier than females without calves. Annual assessments of herd age composition should provide useful information for monitoring the cumulative effects of sea ice changes on walrus reproductive success.

### **Subsistence Harvest Records for Ice Seals in Alaska, 1960–2010**

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In Alaska, bearded (*Erignathus barbatus*), ringed (*Phoca hispida*), spotted (*P. largha*), and ribbon seals (*Histiophoca fasciata*) are called ice seals because of their association with sea ice. Ice seals are important to Alaska Native subsistence culture for food and oil; skins are used for clothes, boats, and crafts. Harvest levels demonstrate community needs and the information will become more important if climate change or other factors reduce seal availability. Prior to 1972, seal harvest was inadvertently collected annually from most communities as part of a bounty program originally intended to reduce seal competition with fisheries in the Gulf of Alaska. After 1972, the bounty was discontinued and relatively little harvest information has been collected from irregular household surveys conducted by tribal councils, other local governments, and by the Alaska Department of Fish and Game (ADF&G), Subsistence Division. The mean number of surveys collected during 1960-1972 was 26 (range 0-45), whereas during 1973-2010 it was only 3 (range 0-12). The Ice Seal Committee and ADF&G have begun to conduct household surveys in order to document current ice seal harvest by community. Together we are investigating the bounty data and evaluating its comparability to recent survey methods. Recommendations: 1) harvest surveys should be done on an annual basis, 2) surveys should be done in as many communities as possible due to local variability in hunting effort, and 3) consecutive surveys will be needed for 3-5 years to identify harvest trends and community needs.

### **Recent visual and acoustic detections of fin and humpback whales in the Alaskan Chukchi Sea**

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Recent visual and acoustic detections of fin and humpback whales in the Alaskan Chukchi Sea may be related to changes in climate. Alternatively, as populations grow, species may be reoccupying ranges inhabited before large-scale removal by commercial whaling. During 2006-2010, 10 sightings of 24 fin whales and 28 sightings of 53 humpback whales were recorded in the Chukchi Sea by observers on vessels. These two species were also detected by acoustic recorders during the same period. At least some of these results may simply reflect recent increases in monitoring effort in the Chukchi Sea related to oil and gas exploration. However, 68% of humpback whale sightings were recorded in 2007 and 2009. These were the two years with the lowest amounts of vessel-based survey effort, but also two of the lowest sea ice extents on record. Fin whales were only observed in 2006, 2008, and 2010, and the frequency of sightings increased over time such that ~60% occurred in 2010. Acoustic monitoring effort also varied among years and was greatest in 2007, 2009, and 2010, the three years with fin whale detections. Fin whale sounds were detected on more days in 2007 (year with lowest recorded ice extent) compared to 2009 and 2010. Humpback sounds were only detected in mid-August 2010. Acoustic recorders also detected a sei whale vocalization in the Chukchi Sea in 2010. Additionally, observers on vessels recorded 5 sightings of 13 Dall's porpoises and a single Steller sea lion in the Chukchi Sea during 2006-2010.

**Seasonal variation of bearded seal (*Erignathus barbatus*) calls north of Barrow, Alaska during the winter and spring of 2010**

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Bearded seals (*Erignathus barbatus*) occupy the Chukchi and Beaufort Seas both seasonally and year-round, yet little is known about their behavior and distribution in this region outside of spring and summer months. We analyzed long-term acoustic recordings collected from December, 2009 through June, 2010 north of Barrow, Alaska, looking for the calls of bearded seals. The month of May had the highest number of calls, while the month of December had the fewest. The acoustic repertoire of bearded seals includes moans, trills and ascents. Moans make up a larger percentage of daily calls in the spring than they do in winter. Trills are common throughout the winter and spring, but trills terminating in plumes are only found in spring. These results show that the bearded seals calling changes seasonally. This seasonal change in acoustic behavior could be an indicator of population migration, breeding behavior, or related to changes in environmental factors, such as sea ice concentration.

**A Tail of Two Tails: Examination and Tissues Analyses of a Seal-Eating Walrus**

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Pacific walrus (*Odobenus rosmarus divergens*) are specialist predators using highly adapted facial musculature to extract benthic bivalves from their shells. However, these pagophilic pinnipeds may feed opportunistically on other available resources, with nutritional stress or unfavorable ice conditions potentially prompting walrus to prey on seals. While not a novel behavior in walrus, reliance on seals as prey appears to be increasing. Climate change in the Arctic and loss of the sea ice resting platform may have unforeseen consequences for pinniped energy budgets, particularly if the prey base is changing. Obtaining samples of "carnivorous" walrus can be difficult and the opportunity to examine and quantify seal-eating by walrus has been limited. We used a combination of analytical techniques to assess the health and diet of an adult male walrus harvested for subsistence use in summer 2011 in Barrow, AK. Specifically, we applied bulk stable isotope analyses of whiskers and muscle, compound-specific stable isotope analysis and profiling of fatty acids from blubber, and blubber lipid content. These chemical analyses were combined with histology, *Trichinella* digestion assays, gross anatomical examination, and classic stomach content analysis. The stomach of this walrus contained remains of two ringed seals (one fresh, one partly digested). We compare these data to subsistence-harvested walrus with a "normal" bivalve diet. Our findings provide insight into the physiological circumstances that may lead to higher trophic level foraging by walrus and, whether a seal-eater is always a seal-eater, as traditional ecological knowledge by Alaskan Native hunters suggests.

### **Conceptual Models: A Tool for Analyzing Cumulative Effects on Marine Mammals**

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Can cumulative effects on marine mammals be modeled? This paper presents some examples of conceptual models that provide a logical, step-wise approach for recognizing linkages among multiple factors that may contribute to a cumulative effect. By using conceptual models to organize information on abundance, distribution, impact thresholds, external stressors, mitigation measures, and regulatory requirements, linkages among them can be made. Matrices can be used to depict relationships between biological thresholds and incremental, cumulative actions that may trigger a marine mammal response. While there is much we understand about marine mammal abundance, distribution, behavior, etc., there are still many data gaps. By understanding interactions among varying environmental factors, we may be able to distill what data are critical for management of the species. Conceptual models can assist us in providing transparent documentation of the relative contribution that certain stressors may have towards a cumulative effect. Insight to the relative weight each contributing factor may have on a cumulative effect provides resource managers an advantage when decisions must be made regarding future conservation of marine mammal populations.

### **Acoustic detections of bowhead and beluga whales in the Beaufort Sea and Chukchi Plateau 2008-2009**

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Bowhead (*Balaena mysticetus*) and beluga (*Delphinapterus leucas*) whales are the only Arctic endemic marine mammals that occur regularly in the Beaufort and Chukchi Seas. Each species winters in the Bering Sea and migrates northwards in the spring, returning south in the late autumn. Bowhead whales form a single population while belugas are considered two separate populations. In order to understand the seasonal occurrence of bowhead and beluga whales in the western Beaufort and Chukchi Plateau, hydrophone packages were moored in 50-100m of water from 2008-2009 at four sites along the shelf break. The instruments were on a 30% duty cycle and recorded from 0.1-4.1 kHz from September 2008-September 2009. There was distinct seasonal and geographic variability in the detection of the different species' calls. Both species were detected in fall and declined as ice concentration in the mooring vicinity increased. In the spring, however, bowhead and beluga calls were detected beginning in April when the region was still covered with ice, and continued throughout the summer. Bowhead whale song was only recorded in the early spring, from April until mid-May and progressed from west to east and then northwards by summer. The instrument on the Chukchi Plateau, which was north (75°N) of the other three, only recorded bowheads from May-August and belugas from May-late September. Future directions include 1) can populations of beluga be distinguished acoustically; 2) how does regional oceanography influence the presence of animals in this area?

**Range and depth estimates of bowhead whale calls detected in the Alaskan Beaufort Sea using a vertical array**

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Using spatially-distributed acoustic recorders to localize bowhead whales is expensive and difficult. To determine whether range/depth tracking is feasible from a single location, a 15-element autonomous vertical array was deployed roughly 35 km north of Kaktovik in 2010, alongside a distributed array of Directional Autonomous Seafloor Acoustic Recorders (DASARs). Matched-field processing and geoacoustic inversion techniques were used to estimate the range, depth, and propagation environment from a whale call at 1.2 km range and 44 m depth in 55 m deep water. The derived propagation model was then used to estimate the group and phase velocities of the normal modes in the region. The vertical array spanned sufficient aperture in the water column to permit isolation of the first and second mode arrivals from any given call. A range- and frequency-dependent phase shift was applied to each modal arrival to remove geometric dispersion effects. The modeled range that time-aligned the modal arrivals was selected as the range estimate. The modal filtering technique is demonstrated on additional whale calls produced at 7.5, 17.3 and 35 km range from the vertical array, with the range estimates independently confirmed by triangulating bearings of call detections on surrounding DASARs. The relative amplitudes of the isolated modal arrivals permit estimation of the calling whales' depths at ranges less than 10 km. The relative advantages/disadvantages of modal filtering methods vs. standard matched-field processing techniques are discussed. [Work supported by NPRB, SEPCO, and Greeneridge Sciences]

**Isotopic ( $\delta^{13}\text{C}$ ,  $\delta^{15}\text{N}$ ,  $\delta^{34}\text{S}$ ) variation of Beaufort Sea Polar Bear tissues**

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Polar bears in the Southern Beaufort Sea subpopulation (SB) are spending increased time on the coastal North Slope of Alaska between July and October. This change in polar bear ecology maybe related to a host of parameters including reduction in sea ice or food available from at bone piles of harvested bowhead whales on the North Slope. We are interested in any changes in feeding ecology and in the fundamental isotopic properties of different tissues and whether interannual variation is evident in apparent diets and whether this may be associated with years of relatively high or low sea ice. We have collect samples over the past 5 years and have undertaken analyses on hair, fat, and blood of male and female bears and their likely and possible prey.

We have found that: a) serum is typically enriched in  $\delta^{15}\text{N}$  compared to red blood cells and hair by up to 6 per mil, b) interannual differences in serum, blood and hair are minimal for  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , and c) the variance between the  $\delta^{15}\text{N}$  values of individual bears was however greatest in 2009. This variability suggests the possibility that some bears may be using a mixture of terrestrial and marine diets or that there are differences in the degree of in situ catabolism associated with fasting or differences in the degree to which individual bears are consuming prey fat as opposed to prey muscle.

## Posters: Bering Sea and Aleutian Islands

### *Bering Sea - Ecosystem Perspectives*

#### **Introducing the Aleutian and Bering Sea Islands Landscape Conservation Cooperative**

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As one of a nationwide network of 22 Landscape Conservation Cooperatives (LCCs), the Aleutian and Bering Sea Islands (ABSI LCC) is in the early stages of development. LCCs are applied conservation partnerships focused on a defined geographic area that inform on-the-ground strategic conservation efforts at landscape scales, with an emphasis on climate change. LCC partners include federal agencies, states, Native and tribal entities, non-governmental organizations, universities and others. The geographic scope of the ABSI LCC includes the islands of the Aleutian archipelago from Attu Island to Unimak Pass, the Pribilof Islands of St. Paul and St. George, St. Matthew Island, and St. Lawrence Island. Strong partnerships already exist to address many of the resource management related concerns throughout the area. The ABSI LCC will not duplicate or assume the authority of any of the existing partnerships rather it will seek to find efficiencies through collaboration and through the collection of additional science products to address conservation concerns shared by the cooperative's partners. With so many strong partnerships in place, the challenge for the ABSI LCC will be to bring these multiple science efforts together to identify shared goals and consider how climate change may add new dimensions to existing resource challenges and to seek ways to appropriately integrate this science with ongoing efforts.

#### **Igniting scientific inquiry in Alaska Native and rural students through Ocean Science Fair participation**

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COSEE Alaska is a consortium of ocean scientists and educators focusing on people, oceans and climate change, weaving together western science and traditional knowledge about ocean climate change. A primary goal is to increase participation of underserved and underrepresented audiences in ocean sciences by helping rural coastal school districts organize regional science fairs related to local knowledge of oceans, fisheries and marine environments in a changing climate. COSEE Alaska's ocean science fair initiative is coordinated through the Center for Cross-Cultural Studies and the Alaska Native Knowledge Network at the University of Alaska Fairbanks. In 2009 and 2010, statewide planning launched a series of local and regional ocean science fairs coastal school districts. Projects were judged by scientists and elders for scientific rigor and cultural relevance. Top projects entered the Alaska State Science Fair. COSEE Alaska provides workshops for teachers and has developed sample ideas for ocean-oriented science fair projects, prepared video samples of exemplary projects, and organized an ocean science theme for the annual Alaska State Science Fair. Guidelines and resources for these fairs are posted on the web. More than 50 projects were judged at the statewide 2010 Fair using western science and cultural relevance/traditional knowledge as criteria. This was a significant increase from 2009. This effort will continue in 2011 and 2012 with ongoing support from COSEE Alaska with funding from the National Science Foundation. The poster being presented will include student work and program evaluation information.

**Incorporating bioenergetics into multi-species statistical catch-at-age models: An example from the Bering Sea**

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Understanding how climatic forces shape the ecology and behavior of marine species is fundamental to predicting how anthropogenic activities may further impair, or conversely, improve the recovery of populations of concern. Thus ecology has increasingly focused on direct and indirect connections between the behavior and survival of species and their physical environments. As the scope and scale of ecological studies has expanded so too has institutional knowledge of the importance of variability, physical disturbances, and food-web-, habitat-, and species- diversity to ecosystem structure. The importance of such biocomplexity to the natural world has similarly translated into the design and implementation of stock-assessment models used for fisheries management; increasingly, there is a movement away from single species management towards multi-species and/or ecosystem process-based approaches. A variety of tools have emerged to address such management needs, including multi-species age-structured statistical models (MSM). MSM combines traditional catch-at-age stock assessment models with multispecies virtual population analysis models (MSVPA) in a Bayesian framework and uses various abundance and diet data (e.g., catch-at-age data, predator diet information) to estimate fishing mortality, recruitment, stock size, suitability coefficients and predation mortality. Such an approach also provides a statistical framework to evaluate and manage both the direct and indirect effects of fisheries harvest on multiple species. However, previous iterations of the model used static predator rations to predict species interactions and were therefore unable to capture climatic driven changes in predation and fishing impacts. In this study, we modified an existing MSM for the Bering Sea to incorporate temperature dependent predator rations estimated using bioenergetics models. The results of the model were used to compare fishing impacts during various thermal regimes and provide an example of how multi-species models can be used to manage ecosystems in fluctuating climatic conditions.

**Blue king crab recovery: Examining marine community differences between St. Matthew Island and the Pribilof Islands**

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The Pribilof Island blue king crab fishery was closed in 1999 and, despite attempts at rebuilding, the stock has continued to decline. In contrast, the St. Matthew blue king crab stock successfully rebuilt over a similar period and was opened to fishing in 2010. I explored three hypotheses comparing these two regions. 1) Does community structure differ between St. Matthew and the Pribilof Islands; 2) Does community structure change over time due to either increases in red king crab abundances or environmental shifts like El Nino; 3) Do changes in environmental factors correlate with differences in community structure? I calculated ecological distances (Bray-Curtis) among NOAA Bering Sea summer trawl survey stations and compared them using ANOSIM, SIMPER and nMDS analyses. I examined relationships between environmental variables and ecological distances using a Mantel test. Community structure differed between the two regions (ANOSIM,  $p=0.001$ ) and changed over time within regions and between regions (ANOSIM,  $p=0.001$  for all four tests). Depth, latitude, and temperature correlated most with observed differences (62%). SIMPER indicated that pollock and groundfish abundance drove most of these differences. As abundance of several groundfish species was consistently higher near the Pribilof Islands than around St. Matthew, it is possible predation by these species prevented blue king crab recovery. In conclusion, community structure differs significantly between regions, these differences do not weaken over time, and they correlate with changes in environmental parameters. Thus blue king crab recovery may be tied to these parameters, necessitating an ecosystem-based approach to rebuilding efforts.

**Carbon cycling in the Bering Sea benthos: Gaining insight from fatty acids**

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As sea ice conditions change in a warming climate, the future of ice-associated Arctic pinnipeds becomes increasingly uncertain. Pacific walrus (*Odobenus rosmarus divergens*) feed on benthic invertebrates that rely on organic carbon fixed by sea ice and pelagic primary producers. Changes in the timing, amount, and partitioning of organic carbon may influence benthic prey availability in future years. Our aim was to characterize contributions of sympagic and pelagic carbon to the benthic food web, including walrus, in the Bering Sea based on stable isotopic signatures ( $\delta^{13}\text{C}$ ) and relative concentrations of individual fatty acids. Near surface sediment and invertebrate samples were collected between March and July in 2009 and 2010. Walrus blubber was obtained from 2009-2011 subsistence harvests from St. Lawrence Island. Eicosapentaenoic acid (EPA) is a fatty acid produced by ice algae, pelagic phytoplankton, and sediment bacteria. Previous research indicates that  $\delta^{13}\text{C}$  values of EPA differ among these sources, making EPA a useful biomarker to trace sources of primary production. Our preliminary 2010 EPA  $\delta^{13}\text{C}$  values from sediments demonstrate a uniform spatial and temporal signature ( $\delta^{13}\text{C} = -29.0 \pm 1.5$ ,  $n=33$ ) that is similar to walrus blubber ( $\delta^{13}\text{C} = -29.2 \pm 0.95$ ,  $n=12$ ). Additionally,  $\delta^{13}\text{C}$  values of sediment and walrus samples more closely resemble open water particulate organic matter (POM) ( $\delta^{13}\text{C} = -28.3 \pm 0.7$ ,  $n=6$ ) than ice POM ( $\delta^{13}\text{C} = -24.0 \pm 2.6$ ,  $n=6$ ), suggesting walrus may not strongly rely on energy input from ice production.

**Road Map: Managing outcomes in the ecosystem-scale 'Bering Sea Project' marine research program**

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Over the past half-century, in parallel with increasing awareness of ecosystem-scale conservation and science issues in the world's oceans, ecosystem-scale marine research programs have increased in scope and ambition. But the larger the scale of a marine research program, the larger the challenge faced in ensuring ambitious goals are met and broad hypotheses and predictions are fully addressed. The Bering Sea Project provides a current example: this six-year US\$52M integrated ecosystem research program, involving nearly 100 principal investigators working to understand how climate-driven changes in ice cover affect the Bering Sea ecosystem, is currently in the final, "synthesis" phase of its lifespan. To manage the challenge of fully addressing original program goals and objectives, the Bering Sea Project's steering committee and program managers have developed a public, real-time tool we call the "Road Map", designed to (1) put the progress made so far (published or planned papers) in the framework of the Project hypotheses; (2) identify information gaps that need to be filled for hypotheses to be fully addressed, and (3) for each hypothesis, evaluate whether or not "synthesis" has been achieved, and if not, plan how to achieve it within the program timeline. We will describe how this Road Map has been developed and applied, and show its utility in managing outcomes of this large-scale research program.

### **The Bering Sea Project Data Archive**

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The NCAR EOL Computing Data and Software (CDS) Facility is providing data management support and a long-term archive for the North Pacific Research Board (NPRB) Bering Sea Integrated Ecosystem Research Program (BSIERP). EOL is also integrating BSIERP archives with the Bering Sea Ecosystem Study (BEST) archives to form the Bering Sea Project Data Archive. The Bering Sea Project Data Archive home page (<http://beringsea.eol.ucar.edu/>) was developed to be the single access point for information and data selected by category, cruise, and project, or multiples of these. This development is coordinated through the National Science Foundation (NSF), the North Pacific Research Board (NPRB), and the BEST/BSIERP Science Advisory Board (SAB). EOL facilitates dataset submission, archival and sharing among BEST, BSIERP and the larger science community. EOL supports the archiving of data and metadata submitted for BSIERP consistent with the FGDC Biological Data Profile, and stores the discovery level metadata within the EOL Metadata Database and Cyber-infrastructure (EMDAC) system consistent with EOL standards and methodologies for data sets already archived as part of BEST. This poster will describe this long-term, consistent, well-documented archive utilizing "one-stop shopping" for locating and obtaining BSIERP and BEST data, and providing a mechanism for the interoperability and synthesis of data collected by the BSIERP and BEST science teams. This archive provides a legacy of almost 300 datasets from over one hundred scientists working for five years on the Bering Sea Project.

### **Top predators partition the Bering Sea**

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We tracked the movements of pinnipeds and seabirds breeding on the Pribilof Islands (central Bering Sea) and Bogoslof Island (southern Bering Sea) to determine where these central place foragers feed relative to the constraints of distance from land, environmental conditions, and availability of food. A total of 115 northern fur seals, 128 thick-billed murres and 106 black-legged kittiwakes were equipped with GPS and activity tags. Results from 2008 and 2009 showed no overlap in foraging areas for kittiwakes or murres breeding on the two Pribilof Islands despite the islands being within foraging distance of each other. Nor was there any overlap between the foraging areas for seabirds from Bogoslof Island compared to those from the Pribilofs. Foraging ranges of northern fur seals also showed segregation of feeding areas by breeding sites between and within islands. The distinct segregation of feeding areas by breeding colonies and the similarities in segregation between both groups of central place foragers implies a common set of selective mechanisms related to compass orientation of breeding colonies, competition within and between species, predation risk, and energetic constraints associated with distance, prey size and energy content. Our data suggest that immediate environmental conditions may have less effect on broad-scale habitat selection compared to colony orientation and the longer-term selective forces related to foraging costs and predictability of annual environmental conditions. This implies that existing breeding colonies in the Bering Sea may be poorly adapted and unable to respond favourably to global warming and environmental change.

**Spatial Pattern in the Eastern Bering Sea**

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As fisheries management in the United States moves towards an ecosystem-based approach, researchers are faced with the need to define ecosystem units and collect data in a manner that will meet this management need. My research explores the utility of spatial pattern analysis to guide research in support of ecosystem approaches to management. I focus on a geographic region of interest in the Eastern Bering Sea comprised of the outer continental shelf and slope. This region is highly heterogeneous in terms of the geomorphology of the shelf break and system of canyons that incise the shelf. I use spatial pattern analysis and landscape metrics to characterize spatial heterogeneity in both physical and biological variables within this focal region. I seek to detect spatial pattern in physical and biological variables, to determine the characteristic scales of variation in these patterns, and to estimate the amount of spatial variation in process variables that may be explained by underlying spatial structure. This research tests the utility of spatial pattern analysis in ecosystem approaches to management and may improve understanding of ecosystem processes in the Eastern Bering Sea.

**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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The research purpose was to study *Trichinella* prevalence in marine mammals and ways of transmission of trichinellosis to humans in a subsistence economy. In 2010 expedition we studied *Trichinella* prevalence in marine mammals, synanthropic and domestic animals living near Chukotka District coastal villages and in them. We tested 343 animals. Eight out of 16 tested species (50.0%) were *Trichinella* carriers. *Trichinella* prevalence varied between 1.6% and 92.8% depending on species. Two marine species were found to be infected: bearded seal and ringed seal. Both were harvested in the Mechigmenski Lagoon. We studied trophic links and modes of *Trichinella* transmission among the Arctic invertebrates and vertebrates and found out that they are able to digest both decapsulated and encapsulated trichinae. The residence time of trichinae, their viability and infectivity varied greatly across host species. We conducted a serological survey in 245 human individuals of Lorino and Lavrentiya using 2 types of antigens. One was prepared from *Trichinella spiralis spiralis* strain. The other was prepared from *Trichinella spiralis nativa* strain isolated from muscles of Arctic animals. Differences in sensitivity of the native people to the above-mentioned types of antigen were substantial. All the cases among the local population had latent or carrier forms of trichinellosis. Native people traditionally cook food from meat of marine mammals and sometimes of terrestrial predators (caged Arctic foxes and dogs). Trichinae remained viable and infective in a traditional food preparation kopalkhen that had been stored in a refrigerator for 4 years 3 months.

**Examining vulnerable seal populations in Lake Iliamna using local knowledge and western science techniques**

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In response to concerns about the absence of information on the status of the seals found within Iliamna Lake, the tribal communities of Iliamna, Kokhanok, Newhalen, Levelock, and Igiugig, in partnership with Bristol Bay Native Association, UAA, ADFG, and NOAA have gathered baseline information on seasonal shifts in abundance and distribution of the unique freshwater seal population, and documented subsistence use patterns and local traditional knowledge (LTK) from communities that traditionally harvest seals from the lake. To assess harvest levels and changes in subsistence use patterns, team members worked with local research assistants to conduct subsistence household surveys (SHS) and a few key respondent interviews. These data from 2009-2011 are compared data to SHS data collected by ADFG in 2004 and 2005. Traditional knowledge about seal abundance and habitat use was also compared with that obtained through aerial surveys flown prior to spring ice breakup, during seal pupping and molting periods, and prior to fall ice formation. Aerial surveys suggested that seal abundance and use of the lake is highly variable seasonally. This project will continue to work with communities to integrate western and local knowledge, so that an accurate synthetic understanding of the role of seals in the human and lake ecosystem can be developed.

**Climate change and fisher location choice in the Pacific cod longline fishery**

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Pacific cod is an economically important groundfish that is targeted by trawl, pot, and longline gear in waters off Alaska. An important part of the Bering Sea Aleutian Islands (BSAI) fishery is the "freezer longliner" sector which in 2008 accounted for \$220 million of the Pacific cod first wholesale value of \$435 million. The timing and location of winter fishing has shifted dramatically since 2000. This shift is related to the extent of seasonal sea ice, as well as the timing of its descent and retreat. The presence of winter ice cover restricts access to a portion of the fishing grounds and affects relative spatial catch per unit effort (CPUE) by causing a cold pool (water less than 2°C that persists into the summer) that Pacific cod avoid. The cold pool is larger in years characterized by a large and persistent sea ice extent. Finally, climate conditions and sea ice may have lagged effects on harvesters' revenue through its effect on recruitment, survival, total biomass, and distribution of size and age classes. The availability and location of different size classes of cod, as well as the demand for these products, affects harvester's decisions about where to fish, what products to produce, and their revenue. Understanding the relationship between fishing location and climate variables is essential in predicting the effects of future warming on the Pacific cod fishery. Here we examine the relationship between the location of the fishery, changing abundance, and changing sea ice.

**A new "knowledge economy": The re-valorization of subsistence hunting techniques for marine mammal monitoring in the Arctic**

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Changes in the extent and predictability of arctic sea ice are having material effects on the subsistence lifeways of indigenous communities in the Bering Strait region of Alaska, which have traditionally relied heavily on marine mammals. At the same time, increased scientific interest in local observations of marine mammals supports a new "knowledge economy" in Alaska Native villages that draws on the expertise of hunters. I take an anthropological approach to the emergence of this knowledge economy as it relates to biological research on walrus and polar bears, and ask: How are hunters' knowledge and skills being redeployed for the purpose of bio-monitoring arctic marine mammals? What are the local cultural and social effects of this new economy? In order to answer these questions, I am currently conducting 12 months of participant observation and interviews on the Bering Strait region, in collaboration with the Alaska Nanuuq Commission. In this poster I show that, in addition to drawing on Traditional Ecological Knowledge (TEK), scientists are increasingly relying on the skills of subsistence hunters in order to locate and sample marine mammals for bio-monitoring. Subsistence techniques are thus being culturally revalorized within a resource management context. However, hunters continue to struggle in order to secure a "fair price" for their contributions. Furthermore, resource management concerns about declining walrus and polar bear populations mean that hunters must navigate legal monitoring of their subsistence activities even as those subsistence activities become essential to the monitoring of marine life.

### **From Sea to Shore –The Benefits of Ship-Based Teacher Research Experiences**

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Every year, teachers from across the United States leave the warmth and comfort of their homes and schools behind for weeks at a time to join scientists on ship-based expeditions to polar regions. It is here among the winds, waves, and breaking ice that they've push themselves to new areas of discovery and taken on the role of student to experience oceanographic science first-hand through a Teacher Research Experience (TRE). TRE's are powerful professional development opportunities, taking teachers out of the classroom and putting them into field experiences and collaborative relationships with scientists towards the shared goal of increasing the understanding of our polar oceans. Participating teachers' often return from their expeditions empowered with new purpose and conviction for their teaching, oodles of classroom material, and a newfound network of scientific content experts. Sharing their discoveries, the teachers' experiences have engaged students in active and meaningful learning and inspired the next generation of scientists and citizens. The Arctic Research Consortium of the U.S. (ARCUS) has been supporting TRE's through a program called PolarTREC (Teachers and Researchers Exploring and Collaborating). Many of the ship-based experiences have taken place in the Bering, Chukchi, and Beaufort seas. Using current technology, teachers shared their adventures before, during, and after the field experience with classrooms, families, and the public taking their audiences to new places through virtual learning. Teachers taking risks out of their comfort zones, has inspired students' ambitions and learning.

### **Large-scale Arctic climate data recovery at the US National Archives**

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To understand the physical processes related to lower-frequency climate variability in the North Pacific - Arctic region we need longer, higher resolution and spatially comprehensive data sets. In principle these may be built using historical observations. Millions of weather and sea ice observations were recorded by US Navy, Revenue Marine/Coast Guard and Coast Survey officers since the mid-19th century and carefully preserved at the National Archives. These data have not been integrated into any global data set and for this reason have been inaccessible to climate scientists. A first of its kind collaboration between NOAA, the National Archives and thousands of citizen volunteers participating in the Zooniverse - Old Weather project is making the original logbooks and the essential environmental data they contain available online to researchers and historians around the world. The ability to rapidly and economically convert large quantities of manuscript information into usable data is a distinguishing feature of Old Weather ([www.oldweather.org](http://www.oldweather.org)). Citizen volunteers have already transcribed data from more than 665,000 logbook pages from World War I era Royal Navy ships since September 2010. As well as providing direct information about the regional climate, newly digitized observations provide input to future extended sparse-input reanalysis products. With these tools not only will we be equipped to distinguish bellwether climate events from rare but ordinary fluctuations, but we will also have better access to their particular meteorological, oceanographic and dynamical underpinnings and hence the possibility of an improved forecast capability.

### **Online Community Based Ecological Monitoring in the Bering Sea**

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Community-based ecological monitoring is a valuable tool if conducted in a reliable manner. BeringWatch is an online database tool for non-scientists in remote locations to record and communicate environmental and ecological events. Our goal here has been to assess and upgrade three key areas of the BeringWatch program and to refine the operational/expansion strategy: 1) to integrate quality control mechanisms directly into the online system and protocols, including a formalized external expert panel; 2) to facilitate usage by a broader user group within each community through the creation of a "Citizen Sentinel" program; and 3) to refine our data output mechanism to allow maximal exposure of data collection efforts, especially for the purpose of community education and interaction with external scientists. To accomplish these goals, we have focused on one user group, the Aleut Community of St. Paul-Tribal Government-Ecosystem Conservation Office (ECO). We have been working to successfully merge ECO's Island Sentinel Program with BeringWatch, its internet companion, to provide a more effective community monitoring, data communication, and environmental outreach program. Once the system is more fully established in the Bering Sea we envision that it will be implemented in other Alaskan maritime communities, particularly the Gulf of Alaska and arctic regions and will serve as a key bridging mechanism between those communities and the scientific community.

**Integrated primary production in the eastern Bering Sea during late summer/early fall**

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Primary production experiments were carried out during 2009 and 2010 on Bering Aleutian Salmon International Surveys (BASIS) in late summer/ early autumn. Autumn in the Bering Sea is a critical time for young forage fish to increase body mass for winter survival. With the goal of understanding more about how energy flows from phytoplankton to fish, we investigate the base of the food web via phytoplankton growth rates using <sup>13</sup>C inoculated samples collected from the surface down to the 1% light level. We analyze integrated uptake rates of <sup>13</sup>C across oceanographic domains (inner domain = <50m, middle domain = 50-100m, outer domain = 100-200m), and north-south regions over the eastern Bering Sea shelf. Integrated uptake rates are also compared to surface uptake rates, as preliminary analysis suggests a positive correlation between the two. Phytoplankton dynamics during this critical time period may ultimately influence food availability up the food web to forage fish.

**A multivariate analysis of observed and modeled biophysical variability on the Bering Sea shelf: multidecadal hindcasts (1969-2009) and forecasts (2010-2040)**

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Coupled physical/biological models can be used to downscale global climate change to the ecology of subarctic regions, and to explore the bottom-up and top-down effects of that change on the spatial structure of subarctic ecosystems - for example, the relative dominance of large vs. small zooplankton in relation to ice cover. Here we utilize a multivariate statistical approach to extract the emergent properties of a coupled physical/biological hindcast of the Bering Sea for years 1969-2009, which includes multiple episodes of warming and cooling (e.g. the recent cooling of 2003-2009). Specifically, we employ multivariate Empirical Orthogonal Function (EOF) analysis to derive the spatial covariance among physical and biological time series from our simulation. These are compared with EOFs derived from: 1) spatially gridded measurements of the region, collected during the multi-year BASIS and BSIERP/BSIERP field programs; 2) a multidecadal regional forecast of the coupled models, driven by an IPCC global model forecast of 2010-2040.

**Variability in *Calanus* spp. populations on the eastern Bering Sea shelf during the recent cold phase**

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The eastern Bering Sea shelf has been experiencing a sequence of extremely cold years marked by intense ice coverage and late ice retreat since 2008. Distributions of zooplankton communities during these conditions were investigated in 2008-2010 as a part of the collaborative BEST-BSIERP program. *Calanus* spp. were the dominant mesozooplankton copepod species over the eastern Bering Sea middle shelf. Spatial and temporal variability in abundance and stage distributions of *Calanus* spp. copepodites in spring and early summer along the shelf were examined in relation to the seasonally progressing ice retreats. Adult females occurred in early spring, and their abundance was one order of magnitude higher in 2009 than in 2008, indicating a potential for a stronger spawning event in 2009. The recruitment of copepodites coincided with the ice retreat from the southern shelf and was delayed in the north where the ice remained. The delay in development was evident in early summer when younger developmental stages dominated the population in ice-free waters in the north, while older stages occurred in the south. Despite the differences in brood stock, the abundance of copepodites in early summer was lower in 2009 and 2010 than in 2008, suggesting that factors other than reproductive success may have controlled the summer *Calanus* spp. population during this recent cold phase in the Bering Sea.

**The Western Alaska Landscape Conservation Cooperative & management information needs regarding terrestrial-marine linkages**

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The Western Alaska Landscape Conservation Cooperative (W.AK LCC) was initiated in 2010 to promote coordination, dissemination, and development of applied science to inform landscape level conservation, including terrestrial-marine linkages, in the face of landscape scale stressors with a focus on climate change. The W.AK LCC spent 2011 developing its basic governance guidance and identifying key science and information needs for meeting shared management objectives in light of projected climate change impacts. A major step in this process was a Science Workshop the LCC conducted last April. Among the wide range of information needs identified at the workshop, and raised in discussions throughout the year, were needs focusing on terrestrial-marine linkages, especially projections of changes in coastal processes. We discuss the current status of the LCC and its Science Planning process, identify opportunities to engage and provide feedback, and present the coastal systems-associated science and information needs identified at the Science Workshop.

### **The status of the Bering Sea in 2011: Cool**

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In 2011, the Bering shelf experienced moderately heavy ice. Similar to recent years, ice arrived near M2 (56.9°N, 164.1°W) in January and began retreating in April, but areal coverage around M2 did not exceed ~60%. During previous cold years (2007-2010), periods of ~100% coverage occurred in the region. Winter/spring ice coverage in the Bering continues to contrast sharply with summer ice extent in the Arctic, which this year was among the lowest on record. The M2 site was occupied by moorings for the 17th straight year, and for the first time, a pCO<sub>2</sub> sensor was included. Depth-averaged ocean temperatures at M2 remained below the long-term average, but were ~1°C warmer than 2008-10. SST was cold in September, probably because late summer storms, resulting in early deepening of the mixed layer. Historically, the Bering has been dominated with strong year-to-year oscillations between cold and warm conditions. This changed in 2000, when, after February, ice was absent from M2 for 6 years. In 2007, the Bering entered the present cold period. The ice in 2011 was partially due to cold ocean conditions in 2010. The ecosystem responds differently to periods of year-to-year variability than to multi-year variability. Prolonged periods of cold conditions permit buildup of large crustacean zooplankton over the middle shelf. Apparently, multi-year variability allows these zooplankton to remain in the system, while prolonged periods of warm conditions reduce and then prevent them from re-entering the system. These different states are important to the Bering's planktivorous fishes, seabirds, and marine mammals.

### **Developing eddy activity and transport indices for the Bering slope current**

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The Bering Sea responds rapidly to atmospheric perturbations and over the past several decades has experienced extreme variability in both its physical and biological characteristics. These changes can impact organisms that inhabit the region by changing current patterns to which reproductive habits are tuned and can influence recruitment and population dynamics, particularly in marine fishes. To understand how recruitment may be influenced by changing environmental conditions, we developed several indices to characterize transport along and across the Bering Slope and compared them to recruitment variability in five ecologically contrasting species. An index of Bering Slope Current (BSC) eddy activity was derived from maps of sea level anomalies from the Archiving, Validation, and Interpretation of Satellite Oceanographic (AVISO) data, and along-shelf and cross-shelf transport indices were developed using simulations from a Regional Ocean Modeling System (ROMS) ocean circulation model. We expect Greenland halibut, Pacific halibut, arrowtooth flounder, Pacific cod and walleye pollock recruitment to vary in their responses to the different indices due to differences in the length of their pelagic larval durations (PLD), spawning and settlement locations. Higher recruitment is expected in slope-associated species with long PLDs after periods of enhanced along-shelf transport and slope retention, while shelf-associated species with shorter PLDs are expected to benefit from periods of increased cross-shelf transport. In addition to providing valuable information to fisheries scientists and managers, this research will help to understand the influence of projected future climate change on recruitment success in marine fishes.

**2011 Norton Sound Benthic Trawl Survey**

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In the summer of 2011 a benthic trawl survey was conducted in Norton Sound. This triennial survey is used to collect information about the distribution and abundance of demersal fishes and invertebrates with primary focus on red king crab. A total of 121 taxa were identified: purple orange sea stars were the most abundant organism; saffron cod were the most prolific fish and red king crab were the 11th most abundant species. A total of 123 legal male and 123 female red king crab were caught in the standard trawl stations. Red king crab abundance estimates were generated using the area-swept method. Legal male abundance was approximately 1.31 million crab or 3.67 million pounds. The 2011 biomass estimate was 61% greater than the 2008 estimate and 26% greater than the long-term average estimate. Prerecruit-1 male abundance was approximately 0.31 million crab, 55% of the 2008 estimate and 50% of the long-term average estimate. Prerecruit-2 male abundance was approximately 0.43 million crab, only 46% of the 2008 estimate, but similar to the long-term average estimate. The trawl survey enhances our understanding of the benthic organisms in Norton Sound and continues to be an invaluable tool for successfully managing the red king crab fisheries.

**Marine Macroinvertebrates of Alaska: Annotated Checklist**

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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. We are compiling a checklist that will include 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. Another goal of this project is to evaluate the Alaska Fisheries Science Center's bottom-trawl survey database for levels of confidence in invertebrate identifications over the duration of the survey time series. 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.

**Benthic Ostracode Assemblages in the Bering and Chukchi Seas from 1976 to 2010**

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The Bering and Chukchi Sea ecosystems have been affected by climatic and oceanographic changes during the past few decades. In order to further our understanding of these changes, we are analyzing living ostracode assemblages from the Northern Bering Sea collected during research cruises on the Polar Sea (2010), the Healy (2006, 2007, 2009), Alpha Helix (1990, 1994, 1999), Karluk (1978), and the Sea Sounder (1976, 1977, 1978), and from the Chukchi Sea during the COMIDA program (2009, 2010). Many ostracode species have a geographic distribution limited by survival and/or reproductive temperatures, so they are useful monitors of climatic and oceanographic change. A total of 11 and 21 species were identified from the Bering and Chukchi Seas, respectively. The higher ostracode diversity in the Chukchi may be due to the highly variable environmental conditions (i.e. temperatures, surface primary productivity/food availability and salinity), in the Bering Sea. The dominant species in the Bering Sea are *Normanicythere leioderma*, *Sarsicytheridea bradii* and *Semicytherura complanata*, whereas in the Chukchi Sea, *Sarsicytheridea bradii* and *Paracyprideis pseudopunctillata* predominate. Temporal patterns suggest that the Bering Sea assemblage composition has responded to short-term temperature changes. For example, the abundance of *P. pseudopunctillata*, a predominantly Arctic species, decreased from 16-25% in the 1970s to 1% by 2009. This decrease coincided with changes in the Pacific Decadal Oscillation and higher Bering sea-surface temperatures through the mid-2000's. In contrast, *Pectocythere*, a temperate genus, made up ~10% of the Bering assemblage in 1990 but exceeded 30% by 2006, as SSTs rose. Lower SSTs in the late 2000's may have caused the decline in this genus to 10% in 2009 and 2% in 2010. Our results support the idea that recent ocean temperature changes and a reduced sea-ice season in the Bering-Chukchi Sea region are affecting benthic ecosystems. However, because many factors influence biological responses, uncertainty about the impacts of climate change on marine ecosystems and interpretations remain.

**Processes controlling the on-shelf transport of oceanic mesozooplankton populations in the Eastern Bering Sea**

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In the eastern Bering Sea shelf break fronts, sharp horizontal gradients in temperature and salinity, significantly reduce lateral mixing making the cross-shelf advection over the outer-shelf sluggish. Despite such physical obstacles, each year large-sized oceanic copepods, primarily *Neocalanus* spp., dominate the biomass of the outer-shelf zooplankton community. Adult populations of *Neocalanus* spp. require water depths of ~200-2000 meters to reproduce so are unable to complete a full life cycle on the continental shelf. Their naupliar and copepodid stages must, therefore, be transported on and across the shelf. A three-dimensional marine ecosystem models with an embedded float tracking model was employed to explore the mechanisms, timing and location of on-shelf zooplankton transport under a variety of environmental conditions. The strength of the on-shelf transport in the spring was found to be influenced greatly by not only strength of the fronts but by their location relative to the shelf break and by the strength of the U and V components of velocity in the Bering Slope current. Positive V-wind velocities promote on-shelf transport. The influence of the seasonal heating on the frontal strength and location, and thus cross shelf transport of oceanic zooplankton depends on the temperature differentials between the Oceanic and Outer Shelf regions and is greatly impacted by the winter temperature of the shelf waters.

**Sedimentation processes under the seasonal sea ice of the Bering Sea**

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Algal concentrations in the sea ice and water column and sinking rates from sediment traps were measured during the 2008 and 2009 Bering Sea Ecosystem Study spring field campaigns in the ice-covered Bering Sea. Integrated ice algal pigment concentration (mean over both field seasons: 5.0 mg chl a m<sup>-2</sup>) significantly exceeded water column pigment concentrations in the upper 5 m (mean over both field seasons: 3.3 mg chl a m<sup>-2</sup>). The ice algal concentrations are among the highest observed anywhere in the Arctic and related to high surface nutrient concentrations. Sediment traps deployed in 5 m depth revealed mean sinking rates of 3.6 mg chl a m<sup>-2</sup> d<sup>-1</sup>. Sinking rates increased over time from <0.5 mg chl a m<sup>-2</sup> d<sup>-1</sup> in early March to maximum values of up to 27.2 mg chl a m<sup>-2</sup> d<sup>-1</sup> by the end of April. These flux rates and their seasonality are similar to observations in other Arctic shelf seas. The significant concentrations of ice algae produced in the Bering Sea are released during periods of advanced melt and become available to pelagic and benthic consumers in short term events.

**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 multiyear 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 repartitioning 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.

*Bering Sea - Lower Trophic Levels*

**Using muscle cell nuclear RNA to improve condition measurements of walleye pollock, *Theragra chalcogramma*, larvae using flow cytometry**

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A protocol to stain nuclear RNA in muscle cell nuclei of walleye pollock, *Theragra chalcogramma*, larvae was developed for the purpose of improving the classification accuracy of a cell cycle based discriminate analysis model used to measure larval condition. Nuclear RNA and DNA (for cell cycle analysis) in muscle cell nuclei were simultaneously measured using flow cytometry. The proportion of G1 phase nuclei with the potential to progress into the S phase was a RNA based measurement tested as an additional covariate in the discriminate analysis model. Models with and without the RNA based covariate were compared, and overall classification accuracy was improved by 3% when it was used. The most important contribution of the additional covariate was improved classification accuracy (5%) of small larvae (< 6.00 mm standard length) when S and G2 phase cell cycle information alone did not distinctly indicate condition. This is significant because the S and G2 phase fractions of small walleye pollock larvae can be highly variable due to first feeding, and the overlap of sizes of healthy and unhealthy larvae. Accurate assessment of the condition of walleye pollock larvae in the sea will improve understanding of environmental processes affecting their survival, and this knowledge can enhance recruitment models used for managing the fishery.

**Combinning field observations and modeling approaches to examine Greenland halibut (*Reinhardtius hippoglossoides*) early life ecology in the Southeastern Bering Sea**

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Spawning in Greenland halibut occurs along the continental slope and in underwater canyons in the Eastern Bering Sea. It is assumed that these bathymetric features and their associated circulation patterns deliver eggs and larvae to suitable nursery habitats over the continental shelf. However, there have been no directed field studies examining spawning areas and transport of Greenland halibut early life stages in the Bering Sea, nor is it known how large-scale oceanographic forcing modulates specific physical mechanisms of delivery. The present study was undertaken to better define spawning areas of Greenland halibut, to examine development and distribution of eggs and larvae, and to understand the influence of climate variations on interannual patterns of transport, distribution and abundance. Results indicate that eggs occur in Bering and Pribilof Canyons and over the adjacent slope in February and March, suggesting that spawning occurs in these regions. Larvae are present over the slope and outer shelf and shelf in winter and spring and settled juveniles were collected over the shelf in September. Oceanographic modeling approaches (ROMS, NEP4) indicate depth-discrete variations in transport pathways as well as interannual variability in transport trajectories. Overall, results highlight that large-scale atmospheric and oceanographic forcing modulates the specific physical mechanisms of delivery, ultimately varying the degree of slope-shelf connectivity.

**Prevalence and phylogenetic analysis of the parasite *Ichthyophonus* from several marine fish hosts in the NE Pacific.**

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Epizootics involving the parasite *Ichthyophonus* sp. have caused significant losses in fisheries of the northern Atlantic and northeastern Pacific oceans. However, its distribution and routes of transmission remain poorly understood. Prevalence of *Ichthyophonus* sp. varies with host species, location, and year throughout the NE Pacific. Data from 2010-2011 suggest that the parasite has a broad host range and is currently enzootic in the majority of species sampled, but may reach epizootic proportions in certain stocks of Pacific halibut, *Hippoglossus stenolepis*. Previous phylogenetic analysis of the rDNA internal transcribed spacer (ITS) regions indicated that the majority of NE Pacific hosts were infected with closely related types of *Ichthyophonus*. These results suggested that either the ITS sequence does not contain polymorphisms necessary for epizootiological inference at the scale of strain, or that gene flow among *Ichthyophonus* populations from disparate hosts and regions throughout the northern hemisphere is high enough to prevent genetic divergence. Ongoing efforts to characterize ITS variation in *Ichthyophonus* isolates from novel hosts and new regions will provide a more complete description of the parasite's distribution and will identify regions where higher resolution genetic markers need to be developed.

### **Relationship among Groundfish, Crabs, and Trawling in the Bering Sea**

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Bottom trawling is one of the more harmful anthropogenic impacts on marine ecosystems. Among other effects, trawling increases rates of death, injury and exposure of many benthic invertebrates and yields large amounts of fish and invertebrate bycatch, which is discarded. Discards increase food availability to predators and scavengers. Stomach samples from many groundfish (e.g., pollock, cod, many flatfishes) collected in trawled areas in the Bering Sea contains significant amounts of discards. Crabs are afforded some protections from trawling in the Bering Sea. For instance, crab bycatch in groundfish fisheries must be returned to the sea. If trawling favors feeding success of groundfish on prey items shared with crab species, such competition may thwart rebuilding of depleted stocks of crabs. I will estimate relationships between the diets of four groundfish (*Atheresthes stomias*, *Hippoglossus stenolepis*, *Limanda aspera* and *Lepidopsetta polyxystra*), fishing intensity (no, low, medium and high fishing intensity), depth, and substrate type. I expect significantly fewer prey items in disturbed than undisturbed areas, because trawling removes prey and homogenizes benthic habitats, reducing structural complexity and species diversity. I will then modify an existing mass-balance ecosystem model (EcoSim) to reflect differences in consumption with trawling intensity. The model will be used to evaluate impacts on groundfish, crabs, and other ecosystem components in EcoSim and to explore potential future impacts of trawling disturbances. Findings should help fishery managers to gauge the costs and benefits of management tools, such as area closures and gear regulations (e.g., gear modifications) that reduce the intensity of fishing.

### **Climate related changes in the nutritional condition of young-of-the-year pollock from the eastern Bering Sea**

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In winter, fish at high latitudes rely on their endogenous energy supplies to satisfy their metabolic needs and survive until spring when foraging conditions improve. For young-of-the-year (YOY) this problem is particularly acute because provisioning for winter can only occur within a relatively small window of time; after metamorphosis is completed and prior to the onset of winter. This suggests that the quality of forage during the latter part of the growing season is likely to be an important determinant to recruitment success. In the Bering Sea climate-related oceanographic conditions are believed to influence the quality of forage available to young-of-the-year (YOY) walleye pollock. In warm years the available prey are predominately small copepods such as *Oithona* sp. and *Pseudocalanus* sp. while in cold years larger calanoids and euphausiids predominate. Similarly, diets of YOY pollock vary between warm and cold conditions in the Bering Sea. The lipid content of small copepods is significantly lower than that of euphausiids and large copepods. Consequently, we have observed improved nutritional condition of YOY pollock at the end of summer during cold years (4.8 kJ/g wet weight) compared with warm years (3.7 kJ/g). Moreover, this improved condition of YOY pollock in cold years has a direct relationship with recruitment the following summer ( $r^2 = 0.79$ ). Our data suggest that warming conditions in the Bering Sea are likely to lead to reduced recruitment to age-1 for this ecologically and economically important species.

**Development and efficacy of a Chinook salmon excluder device in the Bering Sea pollock trawl fishery**

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Between 2001 and 2007, Chinook salmon bycatch in the Bering Sea pollock trawl fishery increased from approximately 33,000 to nearly 122,000 fish. Bycatch of Chinook salmon dropped dramatically after 2007, and Amendment 91 to the Bering Sea Fishery Management Plan established an annual hard cap of 60,000 Chinook salmon. In addition to regulatory changes, the pollock trawl industry has been working with federal fishery scientists to develop gear modifications designed to reduce the number of salmon that are caught incidental to pollock fishing. A salmon "excluder device" placed in the trawl net shows promise to reduce Chinook salmon bycatch by 30 - 35%. This poster documents the development and provides preliminary analysis of the efficacy of the device in reducing Chinook salmon bycatch in the Bering Sea pollock fishery.

**Disease prevalence and links to metabolic condition in Chinook salmon during the marine migration phase**

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The impact of disease on the body condition and successful return migration of Pacific salmon to their spawning grounds is poorly understood. Both *Renibacterium salmoninarum*, the agent causing bacterial kidney disease, and *Ichthyophonus hoferi*, a marine-derived parasite, have the potential to have devastating consequences for the survival of Pacific salmon. Salmon stocks in Western Alaska are declining for yet unknown reasons, and involvement of disease in these declines cannot be ruled out either due to pathogen-induced mortality, reduced fecundity, or the inability of salmon to successfully migrate and spawn in tributaries. Chinook salmon (*Oncorhynchus tshawytscha*) is a staple of Alaska's fishery and low abundance has led to economic hardships for communities dependent upon them. Collaboration with seafood processors in Dutch Harbor made it possible to obtain samples from Chinook salmon by-caught in the A-season of the Pollock fishery in 2010. A total of 392 samples were collected ranging in total length from less than 250mm to 939mm with 59.5% of fish being female. Quantitation of *R. salmoninarum* and *Ichthyophonus* was conducted by quantitative PCR, and metabolomics analyses were performed on liver and muscle tissue of infected and uninfected individuals. Prevalence of *Ichthyophonus* in salmon cardiac tissue was 1% (4 of 392), while *R. salmoninarum* was not detected in any of the samples. Metabolomic profiles were significantly different between size- and sex-matched individuals that were infected and un-infected with *Ichthyophonus*, suggesting that even low levels of infection during marine migration can have significant impacts on the metabolic condition of Chinook salmon.

### **Evolving perceptions of age-0 walleye pollock distributions**

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Distributions of southeastern Bering Sea age-0 walleye pollock (*Theragra chalcogramma*) have been surveyed and described for several decades. We examine whether recent characterizations of age-0 pollock distributions and diel behavior are consistent with reported patterns in the literature and, if not, whether differences can be attributed to climatic conditions and/or survey location. Data for this analysis were collected during a high-resolution acoustic-trawl-oceanographic survey in 2010 and are compared to 2006-2010 regional BASIS survey and previously-published work. Based on May sea surface temperature (SST) anomalies, 2006-2010 survey data were collected during transition- or cold-years while some previously-published work was collected during warmer SST conditions. The 2010 high-resolution data will be used to examine common assumptions about size differences between near-surface (<30 m depth) and deep fish, whether all fish undergo diel vertical migrations, the extent of vertical migrations, and whether age-0 pollock vertical distribution is affected by oceanographic conditions. Finally, we evaluate how the cumulative understanding of age-0 pollock should inform biological models of the Bering Sea ecosystem and potential survey development.

### **How well can surplus production models estimate FMSY and BMSY for crab stocks?**

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The control rules used to calculate overfishing levels, OFLs, and acceptable biological catches, ABCs, for North Pacific crab stocks rely on estimates for the fishing mortality rate and mature male biomass corresponding to maximum sustainable yield, FMSY and BMSY. There are insufficient data to estimate FMSY and BMSY reliably for any North Pacific crab stock so proxies are used when calculating OFLs and ABCs. For the more data-poor stocks, the proxy for FMSY is the estimate of natural mortality,  $M$ , while that for BMSY is the average survey biomass over a period considered to correspond to BMSY. Annual surplus production can be calculated for many of the data-poor stocks, and could be analysed to estimate FMSY and BMSY. However, it is unclear how accurate such estimates will be. A simulation study based on an operating model parameterized to reflect two North Pacific crab stocks, Bristol Bay red king crab and eastern Bering Sea snow crab is used to examine when it is possible to estimate FMSY and BMSY. Factors considered in the simulations include species biology, and the extent of recruitment, observation, growth and natural mortality variation, while five candidate ways of estimating FMSY and BMSY using data on annual surplus production are explored. Results suggest that estimates are usable for management purposes when observation error is low but that the probability of over-estimating FMSY is high even in the best situations.

### **Recruitment mechanisms for eastern Bering Sea Tanner crab—a geospatial approach**

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Abundance and distributions of adult Tanner crab, *Chionoecetes bairdi*, in the eastern Bering Sea demonstrate long-term cyclical patterns with significant interannual variability. Early-life crab survival to adulthood is hypothesized to be strongly influenced by variable larval advection patterns, resulting from interannual changes in both female distributions and regional advection regimes, as these factors largely determine the benthic habitats, thermal regimes, and predator fields experienced by newly settled crab. To investigate this hypothesis a Regional Ocean Modeling System (ROMS) was employed to simulate Lagrangian larval advection based on observed distributions of reproductive female crab and environmental forcing of near-surface currents over 1978-2004. The 60-day track endpoints were then mapped in ArcGIS and geostatistical methods were employed to compare these predicted crab settling locations against spatial distributions of predator densities (indexed by survey CPUE) for Pacific cod, yellowfin sole and flathead sole, as well as surficial sediment (Tanner crab need soft sediment to bury themselves), near bottom temperatures and distributions of cannibalistic older juvenile crab. Strong year classes of Tanner crab may represent those rare cohorts that successfully run the early-life gauntlet involving thermal constraints, habitat requirements, and predator avoidance. Cyclical recruitment success drive boom-and-bust commercial fisheries for this economically important species.

### **Spatio-temporal variability in simulated advection patterns of larval Tanner crab in the eastern Bering Sea**

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Both the abundance and distribution of adult Tanner crab, *Chionoecetes bairdi*, in the eastern Bering Sea demonstrate large interannual variability with long-term cyclical patterns. We hypothesized that variability in larval advection patterns regulate early life survival and subsequent recruitment to the adult stock, owing to climate-driven interannual shifts in embryo hatching locations and larval advection regimes. To investigate this hypothesis a Regional Ocean Modeling System (ROMS) was employed to simulate Lagrangian larval advection based on both observed distributions of reproductive female crab (starting location for newly hatched larvae) and environmental forcing of near-surface currents. Advection track origins and 60-day endpoints were mapped in ArcGIS and connectivity analyses were conducted. Results indicate significant interannual variability in transport patterns between sub-regions. Retention zones appear to occur within Bristol Bay and near the Pribilof Islands, whereas limited advection occurred within the middle domain. In contrast, the outer domain demonstrated significant scope for advection; floats were transported for markedly longer distances, and both distance and direction demonstrated interannual variability. Retention of larvae in Bristol Bay and the vicinity of the Pribilof Islands is critical to recruitment success for the eastern Bering Sea stock of Tanner crab.

**Utilization of attack scars as a proxy for lamprey abundance and distribution in the eastern Bering Sea**

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Arctic and Pacific lampreys are anadromous species playing ecologically important roles in freshwater and marine environments. These species are critical predators and prey items in food webs, and they interact with several commercially important fishes, as evidenced by scars left on hosts. To date, research efforts in Alaska have focused solely on investigating freshwater aspects of these species and there is an absence of lamprey research related to their parasitic marine phase. As such, basic marine ecological information such as abundance and distribution is virtually unknown. Because lampreys are difficult to capture in the ocean, this study will examine marine lamprey abundance and distribution, using attack scars on Pacific cod as a proxy for actual lampreys. Attack scars on Pacific cod sampled in the 2011 International Pacific Halibut Commission Annual Longline Survey and the National Marine Fisheries Service Annual Eastern Bering Sea Trawl Survey were photographed, and scars will be rated for severity and measured. The results may be useful for understanding basic marine ecology of Pacific and Arctic lampreys, and understanding the biological and economic effects of lampreys on other commercially important fishes.

**Eastern Bering Sea Snow Crab: Observations of Growth & Mating in the Laboratory, 2007–2011**

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Immature male and female snow crab and mature male snow crab were collected from the eastern Bering Sea during summer and/or fall stock assessment surveys in 2007–2010 and transported to Kodiak. Crab were held in chilled flow-through seawater tanks (to ~ 3°C) and fed ad libitum twice weekly until the occurrence of molting, death, or visible symptoms of possible infection with bitter crab disease. Though lab mortality rates were high, due to a long duration of holding until crab molted (average 220 days) and high incidence of possible infection with bitter crab disease in some years, we achieved growth measurements for 16 males and 57 females. Molting occurred between mid-January and mid-May, with the majority of molting taking place in February (53%) and March (37%). The overall average relative growth (% increase from pre-molt carapace width (CW)) was similar between males and females at 19%. There were differing trends between the sexes in terms of crab undergoing the molt to morphometric maturity (terminal molt) relative to crab that molted to another immature stage (immature molt). For male crab, relative growth was similar for crab undergoing either a terminal or immature molt (ANOVA  $P=0.427$ ), whereas for female crab, relative growth was significantly less for crab undergoing a terminal molt (ANOVA  $P<0.001$ ). As opportunity allowed, we paired female crab that molted to maturity with mature or immature male snow crab. Some of the mated females were subsequently processed and estimates of fecundity and sperm reserves were obtained.

**Regime shifts and oscillating control of snow crab, *Chionoecetes opilio*, recruitment in the eastern Bering Sea**

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Regime shifts are prominent features of the physical environment of the eastern Bering Sea, and in recent years have happened in approximately 1977, 1989 and 1999. Average snow crab (*Chionoecetes opilio*) recruitment changed in 1989. Oscillating control models are presented for recruitment that use estimated female survey spawning biomass during the pre-1989 regime. The winter Pacific Decadal Oscillation index is used during the period from 1989-present for one model and another model uses sea surface temperature during the month of May in the Bering Sea during the 1989-1999 regime and tests other covariates for the current regime. The hypothesized mechanism behind these relationships involves the influence of temperature during regimes on the timing of the ice retreat and its associated consequences (e.g. food availability, pelagic vs. benthic dominant ecosystems, length of the pelagic stage in snow crab, and size of cold pool) for the survival of pelagic larvae and juvenile crab.

**Modeling the effect of predation in the eastern Bering Sea fish community**

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Walleye pollock is the most abundant and commercially important groundfish species in the Bering Sea. Commercial fisheries for pollock represent over 40% of the global whitefish production. In addition to its economic value, pollock play an important role in the Bering Sea ecosystem as a prey for many predator species, including the endangered Steller sea lion. Inclusion of ecological processes in fishery management plans is now strongly advocated and in some cases mandated. Explicit incorporation of the effects of predation in the population dynamics of commercially harvested species is a step toward ecosystem-based fisheries management. We modeled the biomass dynamics of eastern Bering Sea walleye pollock, as well as three other groundfish groups (Pacific cod, arrowtooth flounder, and other flatfish species). Predation was modeled as a function of prey and predator biomass to explore potentially important interactions and to quantify the effect of predation in terms of biomass consumed. Biomass dynamics of age-1 pollock were modeled separately from those of adult pollock (age 2+) to allow estimation of the predation effect on juvenile pollock, including cannibalism by adult pollock. Significant improvement in model fits resulted from inclusion of predation on juvenile pollock by conspecific adults and arrowtooth flounder. Preliminary results indicate that predation of juveniles by adult pollock and arrowtooth flounder were of similar magnitude. Nonetheless, simulations indicated that reductions in arrowtooth flounder biomass to one tenth of its current level did not increase pollock biomass significantly.

### **Condition of Bering Sea Chinook Salmon in Fall and Winter**

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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 fall and winter field sampling of Chinook bycatch from southeastern Bering Sea trawl fisheries. Ocean age-1 fish (-.1) sampled in September 2010 averaged 48 mm in length, with lipid content of 3.5% as measured by a fatmeter. Energy content was 1,634 cal/g wet weight. By February 2011 fish sampled from this cohort (now designated as ocean age-2) were 52 mm with 6.7% lipid and energy content of 1,805 cal/g wet weight. (By comparison, age -.2 fish from the previous fall were 63 mm with 7.0% lipid and energy content of 1,898 cal/g wet weight.) The next cohort (the new age -.1 fish in their first winter) were 28 cm with 2.8% lipid and energy content of 1,432 cal/g wet weight. Moisture content, caloric values, and fatmeter measurements were closely correlated with each other and with the size of fish. Diet data will also be presented.

### **Are all eggs equal? Maternal effects on embryo quality in the snow crab, *Chionoecetes opilio***

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Variation in embryo quality associated with maternal effects, including size and age, can be linked with larval characteristics and survival in some marine fish and invertebrates. Females with intermediate shell ages and large sizes have higher fecundity than older, younger, and smaller females in the commercially important eastern Bering Sea snow crab, *Chionoecetes opilio*. The objective of this study was to investigate patterns of variability in egg quality, which could bias egg production-based indices of reproductive potential. Embryo diameter, mean embryo dry weight, and proximate biochemical composition (% C and % N) did not vary significantly with female size or shell condition, and statistical models including these terms explained a low proportion of the overall variance. These results suggest that embryo quality is generally conservative and does not vary with female size or shell condition. We also investigated relationships between fecundity and embryo quality by examining the correlation of % C, % N, mean egg weight, and mean embryo diameter with fecundity. In order to remove effects of female size and shell condition, we used residuals of this relationship. The % C, an index of lipid content, was significantly and positively correlated ( $r=0.38$ ,  $p=0.03$ ) with residual fecundity. Embryo lipid content may be incrementally greater in females with higher than average fecundity due to differences in female condition (e.g., bottom-up effects). Our analysis suggests that variation in embryo quality is small and unlikely to bias indices of egg production.

**What does it take to mate? Comparing gonadosomatic index, methyl farnesoate, and shell condition in eastern Bering Sea snow crab, *Chionoecetes opilio***

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Snow crab *Chionoecetes opilio* are a commercially important species in the eastern Bering Sea, though the stock was declared overfished in 1999; the snow crab fishery continues today in a recovery period targeting recently molted "new-shell" male crabs. "Old-shell" crabs are those that have not likely molted in over a year, with abrasions on their carapace. Little is known about male snow crab reproductive physiology. Males undergo a terminal molt, after which their chela grow larger disproportionate to their carapace. Prior to the terminal molt, males producing spermatophores are "adolescents" while after the terminal molt males are "adults". The molting cycle is energetically expensive and, with new-shell males being targeted, they may not have enough time to accumulate reproductive structures to mate successfully. Our project goal was to examine effects of the molting process on reproduction by measuring structures, as gonadosomatic index (GSI), and hormones, methyl farnesoate (MF), before and after the terminal molt. We measured GSI as the ratio of gonad weight to whole crab weight and measured MF using high performance liquid chromatography (HPLC). Both adolescent and adult new-shell males had significantly lower GSI than old-shell males (ANCOVA,  $p < 0.05$ ). New-shell adolescent males had significantly higher MF levels than old-shell adolescent males (ANCOVA,  $p < 0.05$ ); MF must decrease in juvenile animals before they can molt to maturity. MF levels remained low after the terminal molt. With decreased reproductive indices after the terminal molt, new-shell males may be harvested before contributing to the population gene pool.

### **Erosion mitigated recovery of Kasatochi Island nesting areas, 2008-2011**

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The magnitude, type, and sometimes-prolonged nature of volcanic activity in the Aleutian Islands have shaped the habitats and behavior of local species. Kasatochi volcano, in the Central Aleutians, erupted explosively on August 7<sup>th</sup>, 2008 completely burying all terrestrial habitats, with pyroclastic deposits tens of meters thick. These deposits filled and covered rocky crevices in boulder and talus fields used by the estimated 500,000 seabirds, predominantly Crested Auklets (*Aethia cristatella*) and Least Auklets (*Aethia pusilla*), that nested on the island prior to the 2008 eruption. Wave and gully erosion began to modify the surface mantle of volcanic deposits relatively soon after the eruption, but in the three years since the eruption only 25 percent of the material covering preexisting nesting areas has been exhumed. The location of the newly exposed nesting habitat is generally lower on the slope than the pre eruption colony sites due to the pattern of wave erosion and slumping. Despite the limited quantity and quality of the nesting habitat, nesting success has gradually increased from complete failure in 2009 to an estimated hundred(s) in 2010, and thousand(s) in 2011. While we expect the upward reproductive trend to continue, this exponential rate of increase is likely to level off. As the original coastline is exposed the role of wave action as the primary erosion mechanism will give way to gullying and the rates of nesting habitat exposure may be less predictable.

### **Return of the Short-tailed Albatross**

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The Short-tailed Albatross (*Phoebastria albatrus*) is listed as endangered under the US Endangered Species Act (ESA) due to small population size, and limited breeding range. The Short-tailed Albatross breeds on Torishima and Minami-kojima Islands off Japan and migrates to Alaskan waters during the summer. The NOAA Alaska Fisheries Science Center's Observer Program, in collaboration with the USFWS, instructs observers to carry out seabird, monitoring activities in addition to their recording of bycatch during fishing operations. Using Observer Program seabird sightings and vessel-bird interaction data from 1993-2009, we examined potential vessel interaction threats to the recovery of the population, as well as the frequency and geographic expansion of Short-tailed Albatross sightings. Our data indicate that Short-tailed Albatross sightings increased more than the Short-tailed Albatross population during this time period (6.5% population growth per year), with observer days remaining relatively stable. We also found that incidences of discard feeding and/or vessel following are not increasing disproportionately to population size as the population continues to grow, thus it is unlikely that vessel interactions threaten the STAL population recovery. Lastly, we found that the sightings of Short-tailed Albatross show an eastward expansion since 1993, thus suggesting an expansion of this species within their historic range.

**Breeding Ecology of Kittlitz's Murrelet at Agattu Island, Aleutian Archipelago, Alaska: 2011 Progress Report**

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The Kittlitz's murrelet (*Brachyramphus brevirostris*) is one of the rarest breeding seabirds in the North Pacific and one of the least known in North America. During the final year of a 4-year study on the breeding biology of Kittlitz's murrelets at Agattu Island, we located and monitored 21 nests. During the nestling period, time-lapse cameras were deployed at all nests once the egg hatched and still images were used to quantify chick diets, adult attendance patterns, and nest survival. Both frequency of nest visits and types of fishes provisioned to chicks varied among nests. Of the 21 nests discovered in 2011, six chicks fledged. Chicks fledged at 24-32 days post-hatching and departure masses ranged from 104 to 139 g. Overall nest survival from clutch initiation to fledging of first nest attempts, calculated as the stage-specific rates over the incubation and nestling periods, was  $0.284 \pm 0.143$ . Compared with the three previous years of research on nesting murrelets at Agattu Island (2008-2010), breeding success was greater, chicks fledged at heavier masses, and adults made more frequent nest visits. The continued study of the murrelets breeding in the Aleutian Islands will provide further insight into the breeding biology of this rare and elusive seabird and provides a unique opportunity to elucidate its life history.

**Identifying Nesting Habitat of *Brachyramphus* Murrelets: Old Nests Lead to a New Breeding Record**

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The Kittlitz's murrelet (*Brachyramphus brevirostris*) is one of the least known seabirds in North America. To date, 87 nests (44% of the world's known nests) have been monitored at Agattu Island in the western Aleutians. In 2009, we noted that nests from previous years had dense vegetation (grasses and/or mosses) directly in and around the nest scrape, owing to nitrogen rich fecal material deposited by the nestling. Using these cues, we searched for 'non-active' nests, defined as nests used in previous breeding seasons but not monitored during our research efforts. Breeding use at non-active nests was confirmed by the presence of eggshell fragments, chick remains, and/or a fecal ring. At Agattu, 74 non-active nests were found between 2009-2011. To examine the broader application of using vegetative cues to identify nesting habitat, we searched habitat at Adak Island, located in the central Aleutians, during July and September 2010 and September 2011. Two non-active nests were located in 2010. In 2011, one non-active and three active nests (1 abandoned egg, 2 fecal rings) were discovered. We provide the first breeding record of a *Brachyramphus* murrelet nesting at Adak Island and confirm the utility of using non-active nests. This tool has great potential for identifying the breeding range of murrelets at other Aleutian islands and possibly throughout this species range.

### **Winter migration of red-legged and black-legged kittiwakes from the Pribilof Islands, Alaska**

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Understanding how seabirds utilize oceanic habitats during the non-breeding period is essential for helping to explain trends in population demography, breeding phenology, and pre-breeding body condition. Here, we compare the winter migratory habits of two sympatrically breeding congeners with different foraging strategies during the breeding season: black-legged kittiwakes (*Rissa tridactyla*) which are generalists and red-legged kittiwakes (*R. brevirostris*) which are specialists. Using geolocation loggers, 23 black-legged and 16 red-legged kittiwakes were tracked over the winter of 2010-11 from St George Island in the Bering Sea. The non-breeding distribution was distinctly different between species. The black-legged kittiwakes dispersed widely over the entire North Pacific Basin south of the Aleutian Islands but north of the North Pacific Transition Zone. In contrast, red-legged kittiwakes utilized two distinct regions 1) the western Bering Sea and 2) eastern Bering Sea. Overall, there was only 5% overlap in the 50% utilization distributions of each species during the non-breeding period, indicating that the core wintering habitats of each species are spatially and probably oceanographically distinct. Both species showed a high rate of breeding deferral and low hatching success in the subsequent breeding season signifying the potential for negative carry-over effects from the non-breeding period.

### **Patterns of change in diets of two piscivorous seabird species during 35 years in the Pribilof Islands**

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As upper level predators, seabirds reflect fluctuations in the marine environment that influence their prey supply. Studies of seabird diets thus provide insight into the physical and biological mechanisms that potentially drive population changes in both predators and prey. The eastern Bering Sea shelf, among the most productive marine ecosystems worldwide, has undergone significant restructuring in recent decades that is likely to continue with anticipated climatic change. Over 35 years at two Pribilof Islands, we examined temporal patterns in diet and relationships with oceanographic variables for piscivorous black-legged kittiwakes and thick-billed murre. Diets varied significantly among years and between islands and species. Our dataset affirmed the importance of pollock in kittiwake diets; capelin were absent in diets of either species since the late 1970's. Diets of both species contained more gadids at St. Paul and more squid and euphausiids at St. George, likely reflecting differences in foraging location between islands. We found relationships between kittiwake diet and broad-scale oceanographic variables but not with local physical variables. Almost no time-series data exist on availability and abundance of zooplankton or forage fish such as age-0 pollock, myctophids or sandlance in the Bering Sea. Our measure of diet appears too coarse for detecting complex relationships between local oceanographic variables and seabird responses, but may provide invaluable information about changes in forage fish stocks, which are frequently expensive or difficult to otherwise measure. Future diet analyses should increase emphasis on evaluating caloric input and murre chick diet composition.

**Predicting the spatial abundance of marine organisms - which modeling approach is best?**

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Predictive modeling of the spatial distribution of marine organisms is needed in a large number of management applications including assessing the impact of industrial development, like windfarms or oil and gas extraction, planing marine reserves, and identifying critical habitat for endangered species. Much recent effort has focused on present/absence data, including evaluations of available methods. Instead, we will address the spatial distribution of density (animals/area), which allows answering of more relevant questions and presence/absence distribution alone. Methods can be classified into those using spatial information to interpolate between existing measurements and those using purely environmental habitat variables for prediction. Since many methods include some form of model selection, we use 10-fold cross-validation to assess the performance of predictive models. We use five Alaskan seabird species, covering pelagic as well as coastal species and five different modeling methods: GLMMs, GAMs, MARS, ordinary kriging, and universal kriging. Differences between methods were generally small, but MARS models performed best across species. Considerations other than predictive power may be more important than selection of modeling algorithms. E.g. universal kriging yields information about the spatial distribution of estimation error, but does not help ranking variables by their importance.

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

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The fur seals on St. Paul and Bogoslof Islands have undergone dramatic changes in population numbers over the last few decades, but on opposite trajectories, with the Bogoslof population increasing dramatically. Fur seals from St. Paul may be having difficulty obtaining sufficient food during summer to provision their pups with milk. We tested this hypothesis by calculating area of interest indices as a proxy of foraging patch size for the two islands. In the summer of 2009, we deployed 85 first generation Wildlife Computers Mk10 Daily Diary tags (containing 3 dimensional accelerometers and magnetometers as well as temperature and depth sensors) on lactating northern fur seals. We split the 85 deployments evenly between the two Alaskan islands. The foraging strategies of the fur seals from the two islands was known from previous studies to differ considerably at relatively large scales (i.e., average foraging trip for lactating fur seals in 2009 was ~3 days for Bogoslof and ~7 days for St. Paul), but small scale details were not known until now due to the coarse nature of most tagging studies that work under the data limitations of the ARGOS network. The Daily Diary units took data 16 times a second, which were combined with GPS data and the appropriate dead reckoning calculations to obtain fine scaled information on location and relative activity between GPS points. These data provide detailed activity budgets, fine-scale foraging behavior and energy expenditure of northern fur seals.

**Killer whales predation off Severnoe rookery, the Commander Islands, Russia**

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From June 1 to August 14 totally 250 hours of observation were done from the observation towers located on Severnoe rookery of Bering Island (the Commander Islands, Russia). The killer whales (KW) were observed during 28 days. Based on photo ID, at least 3 groups of KW preyed on northern fur seals (NFS) near Severnoe rookery during summer 2011. The 1st group (8 animals, 2 adult males, 1 calf) of mammal-eating KW was observed from June 12 to June 21 (during 5 days) near Severnoe rookery, but we did not observe any predation activity. This group came again on July 1 and preyed exclusively on NFS almost every day (11 days) up to July 15. Second group of 6 (2 calves) mammal-eating KW was observed on July 16-18. The 3d group of 5 (1 adult male, 2 calves) mammal-eating KW was observed on July 22,23,25,26 preying on NFS. Another group of KW were observed on July 29, July 30 and August, but the weather conditions did not allow us to photo-identify individuals, so we could not be sure whether it is a new group or one of the previous groups. Severnoe rookery of Bering Island were often visited by KW during the summer of 2011. Probably, NFS is a dominant prey for mammal-eating killer whales near the Commander Islands at least during summer time.

**Steller sea lion (*Eumetopias jubatus*) demographic studies in Russian waters**

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Steller sea lions (SSL) underwent a mysterious decline throughout most of their range in the late 20th century. The decline has abated or reversed in much of Alaska, but continues in the western Aleutian Islands. Although there is no demographic data available for this area there are vital rates estimates for rookeries to the west in the Russian population. Here, we present the first results from a long-term study that may provide life history data useful to sea lion management in Alaska. We used observational data from 7807 SSL pups branded on 10 major rookeries across Russian waters in 1989-2010 to estimate survival and reproductive rates at the major rookery complexes with diverging population trends. Two genetically distinct SSL populations inhabit Russian waters, Asian and Western, divided at longitude 162° E. Annual productivity of the Asian population is <6000 pups. One month survival for pups was high (~95%) while first year survival dropped to 50%. Annual survival of non-pups age 1+ was 80-90% through age 15, then decreased rapidly. Non-pup mortality during the breeding season at rookeries was low (<1%). Approximately 28% of females first pup at age 4 while 75% were pupping at age 5 and 90% at age 6. Mean annual birthrate was 52%, but varied widely (41% - 72%). The current estimated abundance of the Asian population is 25-28,000 including pups. Our demographic studies indicate that the Asian population consists of at least 4 management units with different population trends and movement patterns.

**Synoptic aerial surveys and abundance estimates for ice-associated seals in U.S. and Russian waters**

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Bearded, ribbon, spotted and ringed seals are important subsistence resources for northern coastal Alaska Native communities and are key components of arctic marine ecosystems. They are protected under the Marine Mammal Protection Act and are considered for listing under the Endangered Species Act, yet no current, comprehensive, and reliable estimate of abundance is available for any of the four species. The distributions of these seals are wide and patchy, and the extent, locations and conditions of their sea ice habitats change rapidly. Therefore, any abundance surveys must cover broad areas throughout their contiguous range and must be completed in a relatively short period of time; preferably during the reproductive and molting period when the greatest proportions of the populations are hauled out on the ice and visible. For the last two years, scientists with NOAA's National Marine Mammal Laboratory have been preparing to conduct synoptic aerial surveys (digital photographic, thermal imaging and visual) of the eastern Bering Sea in tandem with Russian researchers employed to survey the western Bering and Okhotsk Seas. Two years of survey effort are required to achieve adequate precision (CV = 0.2) and to ensure that sufficient periods of suitable weather occur during survey period. The surveys for ribbon, spotted and bearded seals will be conducted in the spring of 2012 and 2013. Ringed seals however, use under-snow lairs and have a more coastal, shore-fast ice distribution and so will require a different and dedicated survey strategy.

## *Bering Sea - Mammals*

### **Using telomere length to age northern fur seals, *Callorhinus ursinus*, from the Pribilof Islands, Alaska**

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Telomeres are a repeat sequence found on the ends of eukaryotic chromosomes. They are incompletely replicated each time cell division occurs resulting in degradation of length over time. This makes them a useful indicator of age in many mammal and bird species. As part of a larger study of vital rates, lowerpost-canine teeth were pulled from female northern fur seals, *Callorhinus ursinus*, (NFS) on the Pribilof Islands (N = 103 St. Paul Island, N = 160 St. George Island) and used to determine age. Flipper tissue was also collected from these animals and telomere length determined via QPCR. Analysis showed that telomeres did in fact get shorter with age, and combining telomere length with mass will allow for unaged NFSs to be put into age bins ( $r^2=0.506$ ,  $p=0.000$ , St. Paul;  $r^2=0.585$ ,  $P=0.000$ , St. George). Removing tooth extraction from the capture protocol would result in greater sample sizes for the vital rates work as well as a reduction in handling time and stress for the animals. Telomere length for a given age was longer on St. George Island than on St. Paul Island ( $P=0.001$ ), which might indicate greater stress among St. Paul fur seals. Telomere length has been shown to correlate to life expectancy. Although both populations have been in decline, in recent years the St. George population is declining more slowly than the St. Paul population and was stable in the last two censuses (2008, 2010).

### **Cetacean distribution and abundance in relation to oceanographic domains on the Eastern Bering Sea shelf in June and July of 2002, 2008, and 2010**

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As part of the Bering Sea Project, cetacean surveys were conducted to describe abundance and distribution on the eastern Bering Sea shelf. Three marine mammal observers conducted visual surveys along transect lines sampled during NOAA's walleye pollock assessment cruise in 2008 and 2010. Distribution and abundance is compared to results from a similar survey conducted in 2002; patterns largely match those previously observed. Abundance estimates for 2002, 2008 and 2010 were as follows: 238 (CV=0.63), 469 (CV=0.43), and 690 (CV=0.80) humpback whales, 407 (CV=0.32), 1,743 (CV=0.30), and 1,715 (CV=0.34) fin whales, 367 (CV=0.49), 574 (CV=0.57), and 1,989 (CV=0.66) minke whales, 34,774 (CV=0.53), 17,149 (CV=0.29), and 11,107 (CV=0.30) Dall's porpoise, and 2,031 (CV=0.46), 3,634 (CV=0.41), and 779 (CV=0.62) harbor porpoise. Note, survey area was 18% larger in 2008 and 2010 than in 2002. Abundances are examined by oceanographic domain and year. Humpback whales were concentrated in coastal waters north of Unimak Pass. Fin whales were distributed in the outer domain in 2008 and 2010, but were sparse in 2002. Minke whales were concentrated in the outer domain except for 2002 when they were also found east of the Pribilof Islands. In 2002, Dall's porpoise were sighted on the western edge of the middle domain and in the outer domain, but shifted west in 2008 and possibly in 2010. In 2002 and 2008, harbor porpoise were found in the middle domain with scattered sightings in the outer domain. In 2010, there was a multi-species mix of sightings between Navarin and Pervenets Canyons.

**Northern fur seal (*Callorhinus ursinus*) pup entanglement before and after marine debris beach cleanups on St. George Island, Alaska**

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Entanglement in marine debris can adversely impact marine mammal populations and has been implicated in the decline of northern fur seals on the Pribilof Islands. Increased funding has been allocated for beach cleanups in recent years, however the assumption that a reduction in the amount of debris in fur seal breeding habitat will result in a decrease in fur seal entanglement had not been critically evaluated until now. Data from this study suggest a thorough beach debris cleanup conducted at fur seal rookeries prior to the breeding season is followed by an immediate, detectable reduction in the incidence of entanglement of fur seal pups. Pup entanglement data were collected at South Rookery on St. George Island, Alaska between 2005-2010 and the rookery was cleaned of debris in 2009 and 2010. Debris cleaned from the rookery was sorted into types commonly observed entangling seals and identified to assess nearshore debris composition. An independent samples t-test was used to detect any difference in pup entanglement rates for years before and after beach cleanups. The incidence of entanglement for pups observed during years that marine debris was removed from the study site was significantly lower than years that beach cleanup did not occur ( $p=0.00$ ).

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

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For central place foraging sea birds, extensive competition around breeding areas has been shown to cause localized depletion of prey resources. A recent colonization event by northern fur seals at Bogoslof Island (Alaska, USA), followed by rapid population growth, provided an opportunity to examine this phenomenon in a marine mammal species. Since 1980, the Bogoslof Island population has grown at 43% per year, but recent counts (2005-2007) show growth has slowed to ~13% per year. To assess the impact of this increase in density, fur seal foraging behavior was examined in 1997, 2005, 2006, and 2007 ( $n=57$ ). While most dive characteristics were not different among years, changes were found in space use and movement patterns. Trip durations and travel distances increased successively from 1997 to 2006; but both parameters remained consistent between 2006 and 2007 at levels greater than 3 times 1997 values. The percentage of time females spent at sea increased by 17.5% between 1997 and 2005/2006 and total foraging area increased over 400% during the same period. The changes measured in foraging behavior suggest that increased predator density around Bogoslof Island may have led to localized resource depletion. However, northern fur seals on Bogoslof Island still expend significantly lower foraging effort compared to other larger local colonies, which are currently declining. As northern fur seals are listed as depleted, comparisons between Bogoslof Island and nearby declining colonies with greater foraging effort may provide important insight for understanding the differing population trends of northern fur seals in Alaska.

**A contemporary estimate of reproductive rates in a declining population of northern fur seals**

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Approximately 55% of the world's breeding population of northern fur seals (*Callorhinus ursinus*) is found on the Pribilof Islands in Alaska, where pup production has irregularly declined for unknown reasons since the 1970's. We determined estimates of reproductive rates on one rookery on St. Paul Island in 2008 and 2009. Natality - defined as the proportion of adult females detected in the rookery that gave birth to a pup - was determined from visual observations of parturition or associated maternal behavior in 208 and 217 individually marked females in 2008 and 2009, respectively. Data yielded observed natality estimates of 0.79 in 2008 and 0.88 in 2009. The minimum fertility rate was estimated at  $>0.6$  for 2008 only as the number of pups born divided by the total number of females present, irrespective of reproductive maturity and age. Pup counts were derived from the asymptote of a sigmoid cumulative arrival model fitted to daily cross-sectional counts conducted through the breeding season. Cross-sectional counts of females uncorrected for variable detection rates likely underestimate the true number of females visiting the colony because of the periodic absence of females on foraging trips following the perinatal period. Program MARK was used to generate a single estimate of the female population size during the breeding season using mark-resight techniques applied to a population of marked females using this colony.

**Reproductive timing and median dates of birth of Northern fur seals in 2008 and 2009**

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The majority of the world's breeding population of northern fur seals (*Callorhinus ursinus*) is found on the Pribilof Islands in Alaska. The timing of reproductive events is highly synchronized and consistent between years for this population. Historically, pup births peaked during the first two weeks of July. We calculated median pupping dates for one section of one breeding rookery on St. Paul Island in 2008 and 2009. Daily live pup counts were corrected for estimates of cumulative pup mortalities. Maximum pup counts were derived as asymptotes of sigmoid growth models fitted to corrected daily counts. Median dates of birth calculated as the date closest to 50% of model asymptotes were 17 July in 2008 and 15 July in 2009. Median dates of arrival - typically about one day pre-partum - from individually marked females were 16 July in 2008 and 15 July 2009. These dates occurred 5 to 13 days later than historic reports from 1951 through 1995, suggesting a contemporary delay in the timing of parturition.

**Anisakids (Nematoda: Anisakidae) from stomachs of the Northern fur seals (*Callorhinus ursinus* Linnaeus, 1758) in St. Paul island, Alaska: current state of parasite situation**

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Anisakid nematodes parasitize alimentary tracts of various aquatic vertebrates including Northern fur seals (NFS) (*Callorhinus ursinus*). These parasites have indirect life cycles involving various intermediate/paratenic hosts (crustacea, fish, squids) which are sources of NFS infection. The aim of this study on St. Paul Island, Alaska, was determining the current status of NFS infection with the main species of anisakids. Gastrointestinal tracts of 84 subadult males (SAMs) (3-4 years old) were collected during the annual NFS subsistence harvest in July-August, 2011. All nematodes were collected manually, fixed in 70% ethanol and identified under light microscope. Totally, 675 anisakid specimens were collected and identified. Numbers of stomach nodules and ulcers caused by gastric nematodes were calculated. Totally, 89.2% of NFS were infected with anisakids. Four species in the genera *Anisakis* (*A. simplex*), *Contracaecum* (*C. osculatum*) and *Pseudoterranova* (*P. decipiens*, *P. azarazi*) were found. Prevalence of NFS infection with *Anisakis* was 47.6% (33.3% larvae; 27.4% adults), with *Contracaecum* 23.8% and *Pseudoterranova* 78.6%. Comparison of our prevalence data with similar studies in SAMs in 1998 (Spraker et al., 2003) shows an increase for *Anisakis* (5% to 47.6%), but a decrease for *Contracaecum* (52% to 23.8%) and *Pseudoterranova* (96% to 78.6%). There was a decrease in number of stomach nodules (92% to 9.5%) and crater-like ulcers (24% to 2.3%). Further studies should help in determining whether current differences in prevalence and pathology are related to change in diet of NFS.

***Dipetalonema odendhali* (Nematoda: Filarioidae) from Northern fur seals (*Callorhinus ursinus* Linnaeus, 1758) in St. Paul island, Alaska**

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Filarioides are a group of nematodes parasitizing marine mammals including the Northern fur seals (NFS) (*Callorhinus ursinus* Linnaeus, 1758). Two *Dipetalonema* species in pinnipeds include *D. odendhali*, often found in subcutaneous tissues, intermuscular fascia beneath the parietal peritoneum, and *D. spirocauda*, a heartworm. The life cycle of *D. odendhali* has not been studied; blood-sucking insects or ticks may be intermediate hosts. Pathogenicity of *D. odendhali* in NFS is unknown. Microfilaria of *Dipetalonema* were often found in blood and blubber samples, however, data on prevalence of adult *D. odendhali* have not been published. The aim of our study on St. Paul Island, Alaska, was to determine the prevalence of NFS infection with *D. odendhali*. Skins and blubber samples were collected and examined grossly from subadult males (SAMs) (3-4 years old) during the annual NFS subsistence harvest in July-August, 2011. The pelts of 120 NFS from three rookeries (Lukanin Bay = 26 NFS; Polovina = 29 and Gorbach = 65) were examined. All nematodes were collected manually, fixed in 70% ethanol and identified under light microscope after clarification in lactophenol. Eighteen mature *D. odendhali* specimens (14 females and 4 males) were found. Average prevalence in NFS was 15% (Lukanin = 19.2%; Polovina = 10.3%; Gorbach = 15.4%). Significant differences between NFS infection at three rookeries were not found ( $p=0.622$ ). Intensity of NFS infection was 1 to 3 nematodes per host (aver.= $1.17\pm 0.51$  SD). Further research in NFS would improve our knowledge on these parasites.

**Biology and prevalence of the hookworm (*Uncinaria lucasi* Stiles, 1901) in northern fur seals (*Callorhinus ursinus* Linnaeus, 1758) on St. Paul Island, Alaska**

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Hookworms were discovered first in pinnipeds in the late 1890s. This was in northern fur seal (NFS) (*Callorhinus ursinus*) pups on the Pribilof Islands (St. Paul and St. George), Alaska. These parasites (*Uncinaria lucasi*) were a major cause of pup mortality. Periodic studies through the 1970s indicated over 90% hookworm prevalence in dead pups on some rookeries on St. Paul Is (SPI). In later years, 1990s through 2011, prevalence declined dramatically like the fur seal population. Apparently the decrease in hookworm prevalence is because of diminished numbers of infected seals on SPI; therefore fewer parasites are being "recycled". An usual finding in 2011 was recovery of adult hookworms (1 male and 3 females) in the intestines of a subadult male NFS. In NFS pups on San Miguel Is, California, prevalence is currently high. Probably because of enough infected seals to keep the hookworm life cycle going at a high level. NFS have had a major role in understanding the life cycle of internal parasites in many other animal hosts. The reason is because of discovery of transmammary transmission of hookworms in NFS. This was the first finding of any larval helminth (nematode, fluke, cestode) being transmitted through the mammary system and maturing in offspring.

**Bioenergetics model for estimating food requirements of female Pacific walruses (*Odobenus rosmarus divergens*)**

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Pacific walruses use sea-ice as platforms for resting, nursing and accessing extensive benthic foraging grounds. Summer sea-ice in the Chukchi Sea has decreased substantially in recent decades, causing walruses to alter habitat use and activity patterns which could affect their energy requirements. We developed a bioenergetics model to estimate caloric demand of female walruses, accounting for maintenance, growth, activity (active in-water and hauled-out resting), molt, and reproductive costs. Estimates for non-reproductive females 0 - 12 years-old (65 - 810 kg) ranged from 16,359 - 68,960 kcal d<sup>-1</sup> (74 - 257 kcal d<sup>-1</sup> kg<sup>-1</sup>) when sea-ice was available, assuming animals spent 83% of their time in water. This translated into the energy content of 3,200 - 5,960 clams per day, equivalent to 7 - 8% and 14 - 9% of body mass per day for 5-12 and 2 - 4 year-olds, respectively. Estimated consumption rates of 12-year-olds were minimally affected by pregnancy, but lactation had a large impact, increasing consumption rates to 15% of body mass per day. Increasing proportion of time in water to 93%, as might happen if walruses were required to spend more time foraging during icefree periods, increased daily caloric demand by 7% for non-lactating females. We provide the first bioenergetics-based estimates of energy requirements for walruses and a first step towards establishing bioenergetic linkages between demography and prey requirements that can ultimately be used in predicting this population's response to environmental change.

### **Pacific walrus haulout monitoring 2011**

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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. Walruses rely on both land and sea-ice as platforms for resting, calving, and foraging, though use is highly stratified by sex and age, particularly during summer months. Male walrus are commonly found on summer terrestrial haulouts, while females and calves primarily rely on sea-ice because it offers protection from predators and access to foraging areas. During 2007, females with calves made the first notable move to Alaskan terrestrial haulouts, and again made landfall in 2009-2011. These years coincided with low summer ice cover. The overall goals of our project are to assess attendance, duration, and level of disturbance at terrestrial walrus haulout locations. In 2011, two digital still cameras were mounted at each of five terrestrial Alaskan walrus haulouts in Bristol Bay to establish records at historical haulouts. One camera at each site faced the primary haulout to record animal abundance, duration, and reactions to disturbance. The second camera focused on the immediate water access to the area to record potential disturbances. These camera observations were a non-invasive means to collect data for a long period of time with little to no disturbance to the study animals. In 2012 cameras will be mounted at two emerging haulout locations on the North Slope/Chukchi Sea coast.

### **Plasma haptoglobin concentrations vary by region of capture in free-ranging Steller sea lion pups**

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Haptoglobin (Hp) is an acute phase protein that under normal conditions is either absent from the blood or present at very low levels. Haptoglobin is a non-specific indicator that can increase significantly in response to acute infection, inflammation or trauma. Plasma samples were collected from 415 free-ranging Steller sea lion pups captured on their natal rookery in 2 regions of the western distinct population segment (DPS; Aleutian Islands n=110 and Gulf of Alaska n=100), in Southeast Alaska (eastern DPS n=86) and in Russia (n=119) between 2000 and 2010. Plasma concentrations (mg/ml) of haptoglobin were measured spectrophotometrically on a Spectramax 340PC plate reader using Phase Haptoglobin Colorimetric assay kit (10 minute incubation time at 30C). Plasma Hp levels ranged from undetectable to 10.51 mg/ml. Mean Hp levels ( $\pm$  SE) were significantly higher in Southeast Alaska ( $3.11 \pm 0.16$  mg/ml) than in the Gulf of Alaska ( $1.57 \pm 0.15$  mg/ml), the Aleutian Islands ( $1.29 \pm 0.14$  mg/ml) or in Russia ( $1.76 \pm 0.13$  mg/ml) ( $p < 0.0001$ ). 79% of pups captured in Southeast Alaska had plasma Hp levels higher than 1.5 mg/ml (the previously reported mean for suckling harp seal pups), whereas only 27% of Aleutian Island pups exceeded this chosen threshold. Concentrations seen in Aleutian pups were lower than found in previous studies and could indicate that higher population densities in the eastern DPS may result in an increase of disease prevalence (such as hookworm infections) in young animals compared to animals in the depleted western DPS.

### **Retrospective analysis of perfluorinated alkyl acids in marine mammals from Alaska**

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Wildlife from remote locations have been shown to bioaccumulate perfluorinated alkyl acids (PFAAs) in their tissues. There are a number of studies examining the accumulation of PFAAs in Arctic fauna from Canada, Greenland, and northern Europe; however, there are few studies examining the levels of PFAAs in tissues collected from the Alaskan Arctic. Twelve PFAAs, consisting of perfluorinated carboxylic (PFCA) and sulfonic (PFSA) acids, and the perfluorooctane sulfonate (PFOS) precursor perfluorooctane sulfonamide (PFOSA), were measured in beluga whale (*Delphinapterus leucas*) and northern fur seal (*Callorhinus ursinus*) livers collected in Alaska between 1987 and 2007 to understand their spatial distribution and temporal trends. The beluga livers were from two isolated populations (Cook Inlet and Eastern Chukchi Sea), the fur seal livers were collected from one location, St. Paul Island. Long-chain PFCAs, (9 to 14 carbons), and PFOS were detected in most of the samples (>80%). Cook Inlet belugas had higher concentrations of most PFCAs and PFOS ( $p < 0.05$ ), but a lower median concentration of PFOSA when compared to the Eastern Chukchi Sea belugas ( $p < 0.05$ ). Temporal trends examined in both species indicated that most PFAA concentrations increased in belugas from 1986 to 2006 and in northern fur seals from 1987 to 2007 ( $p < 0.05$ ). This work was made possible because of the collection and banking of samples done through the Alaska Marine Mammal Tissue Archival Project and emphasizes the importance of environmental specimen banks as a sample resource for assessing chemical trends.

### **Lacka mackerel? Is Atka mackerel “good enough” for Steller sea lions?**

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The relatively poor prey quality of walleye pollock has been highlighted as a contributing factor in the decline of Steller sea lions in the Gulf of Alaska and Bering Sea. However, the major food source of the declining sea lion population in the central and western Aleutian Islands is Atka mackerel (*Pleurogrammus monopterygius*). So is Atka mackerel just another “junk food”? We tested this by combining measurements of the seasonal quality of Atka mackerel with estimates of minimum prey requirements and maximum food intake capacity of captive Steller sea lions, and examined the physiological effects of inadequate Atka mackerel intake on their health and condition. We found that Atka mackerel quality changed up to 86% during the year, with fish during certain seasons being nutritionally equivalent to pollock. Seasonal changes in Steller sea lion energy needs during these periods of poor prey quality could thus result in required food intake levels exceeding the estimated maximum food intake capacity. Our feeding studies with captive Steller sea lions demonstrated that animals consuming inadequate levels of low-lipid Atka mackerel lost more lipid reserves than similarly restricted animals consuming high-lipid herring. Results from this multi-faceted approach show there are times of the year when young Steller sea lions may be challenged to acquire sufficient nutrition from a diet dominated by Atka mackerel, regardless of how much is available to them. This has potential health consequences to individual sea lions and overall sea lion numbers.

**Spanning the North Pacific: Steller sea lions at St. Lawrence Is., Nov-Dec 2011**

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Data on Steller sea lion (*Eumetopias jubatus*; SSL) abundance and distribution at Alaskan haulouts in the Bering Strait are sparse. Reports from the 1950s describe late summer/fall use by groups of males that were presumed to have originated from the Aleutian Islands. The largest concentration (approximately 1,000 animals) was reported in September 1953 on southwestern St. Lawrence Island (SLI). In 2003, residents of SLI reported several hundred SSLs hauled out at Sivuonok on the northwestern shore. Although Sivuonok has been used infrequently by small numbers (<20) of animals, the large numbers reported recently and their late attendance (November- December) was novel. Working with the Gambell Tribal Council and Native Corporation, we photographed branded animals to determine their origin and conducted counts at Sivuonok six times during fall 2010. SSLs, nearly all sub-adult and adult males, were present during late fall; the maximum number counted was 262. Eleven branded SSLs were photographed; all were males ranging in age from 4-10 years. Surprisingly, the natal rookeries represented by the brands spanned the North Pacific Ocean from the western Aleutians in Russia to Southeast Alaska. Additionally, two of the branded bulls were seen 4.5 months earlier in the Gulf of Alaska, defending territories. In December, a large group of SSLs were seen feeding near Sivuonok, presumably on arctic cod (*Boreogadus saida*), which simultaneously washed ashore during the feeding event, suggesting they are important prey locally.

**Congenital anomalies in Northern fur seal pups on St. Paul Island, Alaska from 1986 to 2011**

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When populations undergo severe bottle-necks a major concern is loss of genetic diversity which can result in an increase in prevalence of congenital anomalies. The Pribilof Island fur seal (*Callorhinus ursinus*) population has experienced two severe population declines in the mid-1800's and early 1900's. Both of these declines were due to over-harvesting. When overharvesting was controlled populations rebounded. Beginning in the mid-1970's the population began a relentless decline that has continued for the past 40 years in spite of negligible numbers of animals being harvested. To determine if mortality of pups was a factor in this decline pre-weaned dead pups (n=3,178) were collected from rookeries and examined at necropsy from 1986 through 2011. Gross necropsy findings and histologic lesions were used to determine causes of death. Primary cause of death was starvation. Thirty-five different congenital anomalies (27 fatal and 8 nonfatal) were found in seven organ systems in 58 (1.8%) pups. The percentage of congenital anomalies observed now was similar to rates (0.5% to 1.6%) reported for fur seals previously (Keyes 1965, 1977) and slightly greater than rates (1.0%) reported by Leibold (1980) in other animal species. Our results combined with previous work indicating no change in genetic diversity (Dickerson et al. 2010) suggests that two previous population declines caused by over-harvesting probably did not lead to an increase in congenital anomalies or pup mortality and does not play a role in present day decline.

**The sun, moon, wind, and biological imperative—shaping contrasting wintertime migration and foraging strategies of northern fur seals (*Callorhinus ursinus*)**

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Northern fur seals (NFS, *Callorhinus ursinus*) in Alaska are declining and information on winter migration patterns will help aid conservation efforts and management goals. A critical gap in our knowledge is understanding how and why adult males and females utilize different winter habitats during their eight-month hiatus from breeding sites. We investigated migratory movements, behavior, and habitat characteristics of adult males and females by deploying satellite-linked CTD data loggers on adult males, and satellite-dive recorders and transmitters on adult females on St. Paul I. (Pribilof Is.) during October 2009. Initial dispersal occurred between 25 October and 23 November, with most animals departing within a 10-day period. Dispersal patterns, winter foraging habitats and diving behavior differed greatly between sexes. Environmental determinants, such as winter cyclones, upwelling features, mixed-layer depth, ecosystem, and lunar cycle explained some of the movement and diving variability. We speculate that as winter storms intensify and temperatures fall in the subarctic N. Pacific, females, because of their small mass and energetic, thermoregulatory, and physiological constraints, must travel far to the south and east to less physically demanding environments with accessible prey in the surface mixed layer. Males, because of their much larger size and physiological capabilities, can remain in regions farther north and exploit prey at depth below the surface mixed layer. These contrasting strategies segregate the sexes during winter and eliminate potential competition between them. They also expose individuals within the population to conservation and management issues confronting a significant portion of the N. Pacific Ocean.

**A Chronology of Pacific Walrus Tusk Marking as a Management Tool**

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In the last 60 years the Pacific walrus population has attracted increasing conservation interest culminating with an Endangered Species Act listing of "Warranted but Precluded" in 2011. Paramount concerns at this time are a substantial subsistence harvest interacting with sea ice habitat declines. Government agencies have used a variety of marks, metal seals and wire tags attached to the tusks of harvested Pacific walruses to address these and related issues. The marks variously document legal harvest, assist in harvest estimation and help prevent illegal trade of valuable walrus ivory. I use an archive search and telephone interviews with former agency employees to identify those marks in chronological order and summarize their uses. The product is a visual catalogue intended to help identify walrus ivory harvested before and after the Marine Mammals Protection Act of 1972 (Act). The Act authorizes regulations requiring the marking, tagging and reporting of animals harvested by Alaska Natives for subsistence and creation of authentic handicrafts. Walrus ivory harvested after December 21, 1972 must be tagged or marked. Ivory harvested before that time does not. In 1988 the U.S. Fish and Wildlife Service consequently began its Marking, Tagging and Reporting Program (MTRP) for northern sea otters, Pacific walruses and polar bears harvested in Alaska. The MTRP currently uses three tags for Pacific walruses. One type of lead (Pb) tag and one marking system have been discontinued since 1988.

### **Abundance and prey of mammal-eating killer whales in the Aleutian Islands**

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The abundance of "transient" type killer whales from the Aleutian Islands to the Kenai Peninsula has been estimated from surveys conducted in 2001-2003 as 251 (97-644) from line-transect data and as 345 (255-487) from photo-identification data. Here we estimate area-specific abundance from photo-identification data for the eastern and central Aleutian Islands from 2004-10 data using a Bayesian 2-sample mark-recapture method. Abundance in the eastern Aleutians was estimated to be 176 (130-252), including June data when transients are still aggregated in the False Pass/Unimak Island area to hunt gray whales. Abundance in the central Aleutians was estimated to be 90 (48-184). Marine mammal predation observed in the eastern Aleutians has primarily been on gray whales (in spring) and northern fur seals, and also on minke whales and Steller sea lions. In the central Aleutians transients appear to be aggregated in two areas, one of which is the area from the Rat Islands to Kiska Island. In 2006 a transient was observed preying on squid, and in 2010 transients were observed killing a Baird's beaked whale. The Delarof Islands region is the other area with a high density of transients. One group of whales photographed in 2000 near Adak Island has been resighted in the Delarofs in 2005 and 2010, both times at the same location in deep water at the head of a submarine canyon. A satellite-tagged whale in 2010 stayed in this location in deep water for approximately one month, suggesting predation on deep-diving cetaceans such as Baird's beaked whales.

### **Foraging patterns of ice seals in Alaska inferred from fatty acid profiles**

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We analyzed the blubber fatty acid (FA) composition of pagophilic seals (bearded *Erignathus barbatus*, ribbon *Histiophoca fasciata*, ringed *Pusa hispida*, and spotted *Phoca largha*) harvested in northern Alaska between 2003 and 2010 to determine if foraging patterns differed among species and changed over time. We found, as have others, that bearded seal FA profiles (44 FAs > 0.1%) were different from those of the other seals (ANOSIM  $R > 0.91$ ,  $p = 0.001$ ), spotted and ribbon seal FA profiles were similar (ANOSIM  $R = 0.06$ ,  $p = 0.31$ ), and ringed seal FA profiles overlapped slightly with those of spotted and ribbon seals (ANOSIM  $R > 0.48$ ,  $p = 0.001$ ). FA profiles did not change over time with the exception of spotted seals, which were significantly different between the fall-winter months of 2007-08 and 2009-10 (ANOSIM  $R = 0.46$ ,  $p = 0.001$ ). Dramatic changes in ice conditions during 2003-2010 may have changed prey availability, seal diets, and/or food web structure that could be detected as fluctuations in specific dietary FAs in blubber. To investigate this further, we will conduct correlation analyses using specific dietary FA biomarkers and environmental conditions such as sea ice extent, cover, and the timing of ice retreat in the Bering Sea. Additionally, stable carbon isotopes of specific FAs are being analyzed to 1) determine the contribution of ice algae FA to ice seal FA, and 2) evaluate the significance of diminishing sea ice in the Arctic to ecosystem productivity.

## Bering Sea - Mammals

### **The effect of organochlorine contaminants on Steller sea lion (*Eumetopias jubatus*) reproduction and re-sight probability**

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The presence of persistent organic contaminants (OCs) in the habitats of Steller sea lions (SSL) may influence reproductive rates or possibly survival of SSLs. This project's focus is on the relationship between OCs and the recovery of the western stock of SSL at rookeries in the Russian Far East. OCs were measured in 136 hot-branded SSL pups in 2002 (Iony Is. n=26, Yamsky n=33, Medny Is. n=39, Kozlova Cape n=38). The average natality across all rookeries from 2006 -2010 is  $1 \pm 1.173$  pup with a range of 0 -4 pups per female during 5 year period of analysis. The percentages of male SSL pups resighted since 2008 at Yamsky, Medny Is., Kozlova Cape, and Iony Is., are 0%, 80%, 48%, and 0%, and for female SSL pups, 0%, 31%, 35%, and 25%, respectively, without considering resight effort. The high percentage of resights for Medny Is. pups is consistent with that rookery having the lowest concentrations of OCs as compared to all other rookeries for 2002. Measurements for eight PCB congeners in Kozlova pups range between 0.62 and 36 ng/g, wet-wt with a mean concentration of  $6.94 \pm 7.58$  ng/g, wet-wt, which is nearly twice that for all other rookeries in this study. Females at Kozlova (n = 9) have the highest natality among all analyzed rookeries. The relationship between OCs and SSL survival and natality is still unclear; however, these initial data provide some knowledge as to how contaminants may be affecting the recovery of SSL.

### **Hematology values, dive characteristics, and food habits of ribbon and spotted seals in the Bering Sea**

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Information vital to understanding the ecological roles and potential responses of ice-associated seals to climate change (e.g., their physiology, diving behaviors, and food habits) is scarce. In the spring of 2009 and 2010, blood samples were taken from 51 ribbon seals (*Histiophoca fasciata*) and 45 spotted seals (*Phoca largha*) in the Bering Sea. Ribbon seals had higher hemoglobin concentrations and packed cell volume (PCV) levels than spotted seals for all age classes and both sexes. Data from 30 ribbon and 27 spotted seals tagged with satellite-linked dive recorders indicate the majority of spotted seal dives were less than 200 meters. Ribbon seal dives, however, were distributed over a wider range of depths, with some dives exceeding 600 meters. Scats were collected from ribbon and spotted seals in spring 2007-2010. We analyzed food habits based on otoliths, beaks, and invertebrate remains in the scats. Walleye pollock (*Theragra chalcogramma*) and Pacific herring (*Clupea pallasii pallasii*) were the most frequently occurring prey found in ribbon and spotted seal scats. Walleye pollock, which are benthopelagic and live in greater depths (0-1280 m) than Pacific herring (0-475 m), were the most frequently occurring prey in ribbon seals, and Pacific herring were the most frequently occurring prey in spotted seals. These differences in depth distributions of the seals' main prey species correlate with the differences in hematology; the hemoglobin and PCV values, indicators of potential diving performance, were lower in spotted seals, which were feeding on the shallower prey.

## Posters: Gulf of Alaska

### Marine Plastic Debris: A Potential Vector for POPs in the Marine Ecosystem

*Gulf of Alaska - Ecosystem Perspectives*

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Marine debris is one of the major pollutants affecting the marine environment. The buoyant nature of plastics has facilitated its spread by ocean and wind currents, extending from industrialized coast lines to some of the most remote areas throughout the world. Worldwide, plastic litter has had an impact on marine biota; affecting nearly every trophic level from planktivorous fish, to seabirds, and marine mammals. These organisms have been documented to ingest or become entangled in the plastic debris. The ability of plastics to concentrate high quantities of toxic organic contaminants from the marine environment through partitioning has been well documented. These plastics - laden with high levels of contaminants - can be ingested, possibly making them bioavailable to organisms. The bioavailability and efficiency of transfer of the ingested Persistent Organic Pollutants (POPs) and the potential damage to the marine ecosystem is not known. Some evidence suggests a correlation between plastic ingestion and contaminant load in some organisms. This research seeks to better understand the transfer mechanism of organic contaminants, using the model POP phenanthrene. By examining the transfer of phenanthrene from simulated seawater to plastics, and its' desorption from the plastic by simulated digestive fluids, we are attempting to better understand the potential risks that plastics pose as a vector for POPs in the marine ecosystem.

### Using Stable Isotopes to Estimate Glacier Melt-Water Impacts on Nearshore Productivity in the Gulf of Alaska

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Ringed by the continent's tallest coastal mountains, 20% of the Gulf of Alaska (GOA) coastal watershed is covered by glacial ice, and the annual freshwater outflow into the GOA from glacial melt is similar in volume to that of the Mississippi river. Freshwater influx maintains the Alaska Coastal Current, which sustains commercial and subsistence fisheries as well as millions of coastal marine birds and mammals. Nearly half of this freshwater is derived from glacial melt-water, but we know little about how nutrient availability in glacial runoff contributes to marine productivity in glacial-marine ecosystems. To better understand the scale at which glaciers influence productivity in coastal waters, we conducted a pilot study using stable isotopes to track nutrient origins during summer 2011. We collected particulate organic matter, zooplankton, and forage fish near the face of tidewater glaciers in Icy Bay and Disenchantment Bay, southeast Alaska. Samples are currently being analyzed, and we anticipate finding that  $2\text{H}$  and  $13\text{C}$  isotopic composition of lower trophic marine organisms may help trace glacier-derived freshwater nutrients in marine ecosystems owing to the markedly different isotope ratios between glacio-terrestrial versus marine nutrient sources. Given the predicted impact of global warming on glaciers and freshwater flow, this work will enhance our understanding of the role of glaciers on nearshore ecosystems in the Gulf of Alaska.

### **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 will aid in identifying potential causes of change and influence management activity. In 2011 our monitoring program was integrated into a long term monitoring program focusing on Gulf of Alaska Marine Ecosystems 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 that includes both the nearshore and 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 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 can provide understanding into the scale and causes of change within and across ecosystems.

### **Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Hydrocarbon Fingerprinting**

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Persistent organic pollutants (POP) measured during ICIEMAP were assumed to be entirely from anthropogenic sources. However, the hydrocarbons comprise a diverse variety of potential inputs from both natural and anthropogenic origins that complicate the assessment of sources. With active oil and gas production operations occurring in the upper Inlet, the primary task of this ICIEMAP component was to interpret from polynuclear aromatic hydrocarbon (PAH) and aliphatic data, whether marine sediments show evidence of oil releases due to oil industry exploration or production activities. The hydrocarbon patterns in the ICIEMAP samples show three regionally dominant patterns, although the differences among samples suggest mixed sources. As with historical studies, no evidence of PAH accumulations from produced water discharges or recent crude oil or distillate product releases were observed in the sediment samples; however, all samples did contain oil-like signatures from potential peat/coal/source-rock (kerogen) inputs into Cook Inlet. Notably, petrogenic sediment patterns that had been attributed by other scientists as a PAH-bearing, ubiquitous, source-rock signal originating from the Yakutat region and transported across coastal Northern Gulf of Alaska now seem likely to originate from, or at least be supplemented by, local Cook Inlet sources.

**Fecundity of the Euphausiid *Euphausia pacifica* from the North Pacific with a Focus on the Northern California Current and the Gulf of Alaska**

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*Euphausia pacifica* is an important secondary producer in many oceanic and coastal ecosystems ranging throughout the North Pacific. It is a key grazer on phytoplankton and a major prey item for many upper trophic level species, including most commercially harvested fish such as salmon, pollock, herring, and rockfish, as well as seabirds, and whales. This project improved upon the current knowledge of reproductive rates for *E. pacifica* from the Gulf of Alaska by exploring the range of reproductive behaviors exhibited by individual females maintained in a controlled laboratory setting and thereby allowed for direct comparison to other populations maintained in the same setting. We present long term fecundity comparisons carried out in our laboratory between the population from the shelf break off central Oregon to populations from Southern California, the Washington shelf, a deep station in the relatively oligotrophic sub-arctic extension of the North Pacific gyre and from a station near Sitka, Alaska. These experiments suggest a trend of increasing inter-brood period with increasing latitude of female origin. We also show a compilation and analysis of *E. pacifica* brood size data from several geographic regions around the North Pacific. These results help to place our existing fecundity data from Alaska and that published by Pinchuk and Hopcroft (2006) in the context of all known reproductive rates and strategies for *E. pacifica*.

**Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Benthic Infaunal Communities**

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The benthic infaunal component of ICIEMAP was designed to describe Cook Inlet benthic communities and determine if differences between oil industry activity areas and other areas of the Inlet exist. In addition, since benthic communities in much of Cook Inlet were previously poorly studied, other goals included describing the distribution of infaunal assemblages relative to environmental parameters and looking for range extensions or undescribed, non-indigenous, or cryptogenic species. A total of 22,203 animals (>1 mm) were collected at 44 stations (one station in lower Cook Inlet accounted for 60% of total organisms). Annelida comprised 78% of individuals, with the polychaete *Dipolydora quadrilobata* accounting for 5952 individuals. Arthropoda, dominated by the amphipods *Ischyrocercus* sp. and *Photis* sp., comprised about 12% of the total. Mollusca (mostly the bivalves *Ennucula tenuis* and *Axinopsida serricata*) accounted for 8%, and miscellaneous taxa and Echinodermata accounted for <1%. Fifteen species range extensions were documented with 17 potentially undescribed species, five non-indigenous, and few cosmopolitan species occurring throughout the area. Distinct biological communities were found in different portions of Cook Inlet with a strong north to south gradient of increasing species diversity observed. The Upper Cook Inlet and Industry areas have much lower numbers of individuals and taxa, most likely due to the extreme physical conditions. These areas of extreme tidal currents, low salinity, and high turbidity regimes produce environments with low total organic carbon and sediment fines, resulting in suboptimal environments for diverse and productive infaunal communities.

### **Marine Ecosystem-Based Graduate Education in Alaska**

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At the University of Alaska Fairbanks, graduate education in marine science now includes an interdisciplinary program that is geared to address the unique challenges of marine ecosystem-based management and to understand its implications for society. Graduate students gain a broad background in fishery science and management, ecology, marine science, marine policy, economics, traditional ecological knowledge and anthropology to complement their own specialized expertise acquired through dissertation research and study. The program challenges students to develop innovative approaches to pressing real-world problems. Representative student thesis and dissertation topics include investigating responses of coastal fishing communities to environmental changes, marine mammal fishery interactions, economic valuation of marine tourism and commercial fisheries, impacts of trawling on seafloor communities and habitats, and climate-change impacts on Arctic marine food webs. This interdisciplinary MS and PhD program prepares professionals to solve problems arising at the interface between dynamic environmental and social systems and to address ecosystem-based solutions to critical research and stewardship questions in the sustainable use of living marine resources, skills that are critically needed in today's society. National Science Foundation fellowships for the Marine Ecosystem Sustainability in the Arctic and Subarctic (MESAS) program are available for PhD students in Fall 2012 (US citizens and permanent residents only). The program is offered from the Juneau Campus of the School of Fisheries and Ocean Sciences and the main UAF campus in Fairbanks. Please visit <http://www.uaf.edu/mesas> for more information.

### **OBIS-USA: Ocean Biogeographic Information System - Technology, Data, Standards and Applications**

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OBIS-USA, a program of the United States Geological Survey (USGS), is the US national node of the Ocean Biogeographic Information System. OBIS-USA brings together marine biological occurrence data in a standard format, with metadata, web-based discovery and download, and web service access for users and applications.

OBIS-USA provides marine biological occurrences, including taxon, coordinates, and date, plus additional detail as available. OBIS-USA serves US government (all levels), academic, and non-governmental data.

OBIS-USA goes beyond the limits traditionally encountered in biodiversity data. OBIS-USA can integrate application-critical details such as absence, abundance, effort, method, and tracking. Over time, OBIS-USA aims to further identify and innovate yet more categories of important biological observations and details.

OBIS-USA configures the data and web services to enable integration with other data types, such as physical oceanography, water chemistry, climate, and other types.

OBIS-USA currently has over 7 million biological observation records, in almost 150 datasets, representing 38 institutions. OBIS-USA is open to all marine taxa, with over 84,000 taxa already on board. Institutions and datasets from the Alaska region already comprise a significant portion of OBIS-USA, and OBIS-USA looks forward to increasing all aspects of both data and applications that assist marine research in Alaska.

OBIS-USA's poster will facilitate AMSS attendees' opportunity to benefit by contributing data to OBIS-USA or by consuming OBIS-USA data for their research and applications.

**Sample Size, Statistical Power Estimation and Potential Implications for a Long-Term Marine Nearshore Monitoring Program**

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Sample size and statistical power analyses using simulation and Bayesian inference are being conducted for the National Park Service Southwest Alaska Network (SWAN) Inventory and Monitoring Program. The goals of the project are to provide examples of how Bayesian inference can be applied to determining trends in long-term nearshore monitoring data, estimate trends observed in intertidal algae and invertebrates over the first 5 years of monitoring and determine the degree of sampling intensity necessary to estimate trends in the future. Bayesian methods are employed to model simulated datasets which are based on actual monitoring data collected from 2006 to 2010. The output provides a range of sampling levels and statistical power for estimation of trends. Observed survey data are analyzed with Bayesian methods to estimate the annual trend parameter and its precision for each member of a set of candidate models. Model selection based on the deviance information criterion (DIC) is then conducted on the set of candidate models to determine the model best suited for estimating model parameters. New datasets are simulated to which a linear trend has been incorporated at the level for which an estimate of power is needed. The procedure is repeated multiple times and an estimate of power is given as the proportion of simulations that correctly reject the null hypothesis of no trend. The advantages of the Bayesian approach include greater flexibility in modeling complex generalized linear mixed models, allowance for inclusion of model uncertainty, and ease in estimation of precision of functions of trend parameters.

**Sunflower Sea Star (*Pycnopodia helianthoides*) Feeding Behavior at Sea Otter Pits**

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The ferocious predator, *Pycnopodia helianthoides* (sunflower sea star) is known to inhabit sea otter pits located in soft sediment habitats. However, little is known regarding why the 24-rayed sea star so readily migrates to sea otter pits. It is hypothesized that *P. helianthoides* are attracted to sea otter pits due to either light sensors that indicate the pit's depth, chemical sensors that detect alive or damaged bivalves, or by chance. To investigate these possibilities, a series of controlled tests under varying experimental conditions were performed in the intertidal zone in Kasistsna Bay, Alaska. The results suggest that chemical cues are important for *P. helianthoides* feeding, along with the presence of sea otter pits for scavenging. In addition, the results suggest the chemical cues from dead bivalves, versus live clams, stimulate a stronger foraging response from *P. helianthoides*. Consequently, *P. helianthoides* disposition toward dead clams indicates its important role as a scavenger, which undoubtedly affects intertidal and subtidal ecosystems in Alaska.

### **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 mapped dataset includes imagery with geomorphic and biological attributes as a searchable geospatial dataset of coastal habitat features. The imagery provides a useful baseline and visual reference. The mapped features include: shoreline morphology, substrates, and biotic resources such as eelgrass, canopy kelps, salt marshes and other habitat descriptors. The many data applications include: oil spill contingency planning, conservation planning, habitat research and other coastal site evaluations.

Approximately 96,092 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 ~51,745 km of the Alaskan coastline (~69%). The project is on-going with ~23,705 km of Alaska coastline left to be imaged. The Alaska imagery can be viewed online at <http://www.alaskafisheries.noaa.gov/maps/>.

The ShoreZone program is built on a foundation of multiple funding and contributing partners, including state and federal governmental agencies, nonprofit organizations, spill response planners, and industry, as well as other scientists and spatial data specialists. The multi-organization program provides a framework to build on and supports a contiguous, integrated coastal resource database that extends from southern Oregon, through Washington State, British Columbia, Southeast Alaska, the Gulf of Alaska, Alaska Peninsula, Bristol Bay, and northwards along the Bering Sea coastline. The program goal is to have all of the Alaskan shoreline imaged and mapped using the ShoreZone protocol. The partnership is actively seeking additional partners to help accomplish this goal.

**Sediment Quality Triad Assessment in Kachemak Bay and Kenai Peninsula: Characterization of Soft Bottom Benthic Habitats and Contaminant Bioeffects Assessment**

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In 2007, the NOAA Bioeffects Program characterized benthic habitats in northern Kachemak Bay and in 2008 the deep portions of the bay were characterized through the Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP). NOAA and the Alaska DEC are also conducting a bioeffects characterization in Kenai Peninsula fjords to assess habitat conditions influencing the distribution and diversity of infaunal communities by evaluating sediment properties, infaunal distributions, contaminant concentrations, and toxicity. Concentrations of polynuclear aromatic hydrocarbon (PAH) were elevated in Port Graham, Homer and Seldovia Harbors. Outside of harbors, data for PAH and alkane mixtures indicated negligible anthropogenic sources. Metal values were elevated in deep portions of the Bay relative to shallow areas due to grain size differences. Shallow sediments were primarily fine grained with significant amounts of sand present in the west, and less in the east end where sediments from glacial runoff enter the Bay. Deep sediments were muddier. Sediments in the fjords varied by location with some being very sandy and others a mixture of sand and fines. The benthic community in the deep areas of Kachemak Bay was distinctly different, with only 20% of species in common with the sand flats and 25% with the fjords. Unlike shallow areas, the deep benthic community is more uniformly distributed. The fjords contained a variety of habitats, and contained 386 species versus 219 for the sand flats. Communities in Koyuktulik and Chrome bays were distinctly different than study areas within Kachemak Bay.

### **Refined Remote Sensing Technique and Field Survey Data Improve Mapping of Eelgrass Distribution from Satellite Imagery**

**Kyle R. Hogrefe**, khogrefe@usgs.gov, U.S. Geological Survey

Eelgrass (*Zostera marina*) is an essential component of coastal and estuarine ecosystems that needs monitoring due to its susceptibility to loss from direct human impacts and climate change. The U.S. Geological Survey and U.S. Fish & Wildlife Service have launched an inventory and monitoring program to assess eelgrass distribution and abundance in southwest Alaska. The analysis and classification of satellite imagery has been a key component in creating baseline distribution maps of eelgrass beds throughout this region. Problems, however, arise with detection of eelgrass at water depth (>0.5 m) and with differentiation of eelgrass from green seaweeds. Water attenuates spectral signals such that submerged beds of eelgrass become indistinguishable from water, causing misclassification and lowering distribution estimates. Additionally, the spectral signal of eelgrass and green seaweeds are very similar so that areas consisting of seaweeds may be misidentified as eelgrass, increasing distribution estimates. To solve the detection at depth problem, we refined an established classification method (which uses an unsupervised isodata clustering algorithm to identify regions of statistically separable spectral classes and subsequently employs them in a supervised maximum likelihood algorithm) by running multiple iterations of the algorithms with later runs focused on areas previously classified as water. We conducted field surveys at Chignik Lagoon in August 2011 to collect ground truth data for error assessment of our habitat distribution estimate and found that the refined classification method significantly increased accuracy. We also discounted areas of seaweed misidentification as eelgrass through visual assessment to reduce map error.

### **Physical and Biological Characteristics of Kelp Forests in Kachemak Bay, Alaska**

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Along the southern coast of Alaska, two species of canopy-forming kelps, *Nereocystis luetkeana* and *Eualaria fistulosa*, co-occur and have dissimilar morphologies. The differences may affect patterns of water movement and impact patterns of larval delivery and biodiversity. Although these species have overlapping ranges in Alaska their absolute ranges differ, with *N. luetkeana* extending further south. The goal of our research was to determine how currents are affected by these two canopy types and to determine if larval delivery of invertebrates and benthic biodiversity differ between canopy types. Our interest in this study was to assess the possible impacts on biodiversity from changes in dominance of canopy-forming kelps in Kachemak Bay due to future climate changes. Currents were measured over a complete lunar cycle, larval invertebrate biodiversity was determined with weekly sampling over the same time period and benthic biodiversity was quantified with visual and biomass surveys at the conclusion of the study. No significant differences in current modulation were found between kelp forest types. When settlement data were integrated over the study there was no difference in larval settlement between kelp forest types, however multivariate analyses showed that larval settlement differed among the sites, forest types, and location relative to the kelp forest canopy. Benthic biodiversity differed significantly, though this was mainly driven by species of understory kelps. Our results suggest that composition (i.e. species) of canopy-forming kelps in the forests of Kachemak Bay may not have a significant impact on larval settlement.

**Sustainable Ecosystem-Based Management of Living Marine Resources (SELMR)**

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SELMR is an interdisciplinary program supporting the education of future leaders in the ecosystem-based sustainable stewardship of living marine resources. Funding from the National Science Foundation over the last two years has given MS students the opportunity to receive interdisciplinary training in the fundamental principles and analytic tools of fisheries science, oceanography, ecology, economics, management, marine policy, and anthropology. Representative thesis topics include investigating methods to categorize stakeholder input and rate research priorities, marine mammal and commercial fishery interactions, marine mammal contaminant levels, effects of target species abundance on fisheries, and genetic responses of commercially fished species to fishing and climate change. Students from this program gain the tools to tackle the unique challenges of ecosystem-based management, transcending traditional disciplinary boundaries to generate innovative approaches to real-world problems. In today's society there is a growing need for this type of comprehensive approach and the SELMR program provides students with the means and skills to address pressing issues in not only Alaska, but throughout the entire world.

**Alaska ShoreZone Online – A Web Enabled GIS Database**

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The Alaska Regional Office of NOAA Fisheries hosts a web portal to coastal imagery and habitat mapping for the Alaska ShoreZone Program. Through this web portal you can view millions of low altitude images of Alaska's coastline or access detailed coastal habitat classifications in various map layers. High end users can create their own habitat queries and download custom habitat maps. This web portal is available to the public and continues to grow as the Alaska ShoreZone program acquires more imagery and habitat information of the coastline. Providing this online resource has been invaluable to coastal managers, researchers, educators, and the private sector. For more information go to: <http://www.alaskafisheries.noaa.gov/maps>.

### **Distribution and Ecology of Zooplankton and Juvenile Pelagic Fishes in the Copper River Plume**

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The Copper River is the largest point-source of fresh water to the northern Gulf of Alaska, and is an important development environment for a variety of local pelagic fish. Salmon smolts and other juvenile fish are known to subsist on zooplankton, but their location and feeding patterns are little studied in the region. Juvenile fish use the plume to take advantage of concentrated zooplankton populations, and may use the highly turbid water to evade predation. The influence of the plume biochemistry and physical dynamics creates a non-homogeneous distribution of zooplankton and other forage material that correlates with fish feeding behavior, while fluctuations in marine conditions and changes in zooplankton concentrations and fish behavior have been implicated as drivers of year-class strength. We sampled fish and zooplankton across the Copper River plume, and made concurrent measurements of salinity, temperature, and turbidity with an undulating towed vehicle to develop an oceanographic description of the plume. Further description of the trophic status of fish and zooplankton were conducted via gut content and stable isotope analysis, and age and growth rates were estimated from otolith measurements. The relationship between zooplankton and juvenile fish concentrations correlates with plume dynamics in a way that supports optimal juvenile fish growth and survival.

### **Overview and Twenty-Two Year Update of Shoreline Biological Observations in Prince William Sound**

**Alan J. Mearns**, alan.mearns@noaa.gov, National Oceanic and Atmospheric Administration

Humans and Nature conspired to impact marine life of shorelines in Prince William Sound, Alaska during the past 22 years. Algal cover recovered within 3 to 4 years at previously oiled, oiled and cleaned and unoiled sites as well as on bare rock following a winter 2000 rockslide. Continued photo monitoring is revealing a strong 4 to 7-year inter-annual variation in cover of the dominant seaweed *Fucus* spp. at most sites, with episodes of heavy cover (1991-92; 1997 to 2001, and 2005 to 2007) alternating with periods of very low cover (1994-95; 2002-03 and 2008-2011). This longer-term interannual variability might be influenced by interannual variability of oceanic processes in the North Pacific such as revealed by El Nino Southern Oscillation (ENSO) and Pacific Decadal (PDO) indices, which, over the entire two-decade time period, shifted from "warm" to "cold" regimes. In addition, the once-abundant Littleneck clam, after an initial decade of recovery, quite suddenly disappeared early in the 2000's, not only from Prince William Sound but also on gravel shorelines elsewhere in the Northeast Pacific. This suite of long-term shoreline studies reveals that human-caused disasters and natural interannual variability are both entwined in driving variable states of biodiversity and abundance of shoreline marine life in these semi-protected environments. The direction and rate of recovery of shoreline marine life from oil spills may depend on what "state" the system is experiencing at the time, and the "state" Continued photo-monitoring and clam sampling by

toward which it is heading. local citizens, skippers and scientists, with local archival of data, could be useful in exploring and understanding biological variability in the face of climate change and other events that may befall the region in the future.

### **Long-Term Marine Monitoring at National Parks in Southeast Alaska**

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Comprising the three national parks of Southeast Alaska - Glacier Bay National Park and Preserve, Klondike Goldrush National Historical Park, and Sitka National Historical Park - the Southeast Alaska Network is charged with designing and implementing rigorous long-term ecological monitoring programs. This poster offers an update and overview of a number of on-going marine-related monitoring and research efforts, including physical oceanography, ocean acidification, marine contaminants, Kittlitz's murrelets, and black-legged kittiwakes.

### **Gulf of Alaska IERP Retrospective Data Project**

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Retrospective analyses are an integral part of each of the major components of the GOA-IERP. This project seeks to coordinate efforts of individual components into one cohesive plan that ultimately describes the historical physical and biological characteristics across the Gulf of Alaska. Primary objectives are to assess spatial and temporal variability in the ecosystem, primarily between the eastern and western GOA regions and to use historical datasets to analyze temporal variability in potential climatic, oceanographic, or biological drivers influencing the early life survival of five focal groundfish species. Preliminary results include the identification of 100 available historical datasets, development of early life history summaries for the focal species, evaluation of spatial and temporal trends in egg/larval distributions of the focal species, EOF analysis of satellite derived sea surface temperature and chlorophyll-a datasets, and an analysis of recent spatial and temporal trends in groundfish communities based on bottom trawl survey data. Products from the retrospective project will ultimately (1) provide historical context for new observations and measurements, (2) quantify spatial and temporal variability in key physical and biological characteristics of the coastal GOA, (3) elucidate relationships between physical and biological drivers of recruitment and upper trophic level variability, (4) test a priori hypotheses about these relationships, and (5) develop new hypotheses for field biologists and modelers to test in the future.

**Fecal Pathogen Pollution: Sources and Patterns in Water and Sediment Samples from the Upper Cook Inlet, Alaska ecosystem**

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Concern has grown regarding water quality in Cook Inlet (CI), Alaska, for local human health and endangered CI belugas (*Delphinapterus leucas*). Upper CI, Alaska's major urban center, receives wastewater effluents that may contain organic and inorganic pollutants including bacteria, protozoa, and viruses. Relatively little is understood about the ecology and source of fecal pathogens entering CI's nearshore aquatic environment, though it is recognized fecal by-products from humans, domestic animals, and wildlife, may affect water quality and food resources. As a complement to conventional indicator bacteria testing, monitoring for the presence of fecal pathogens, and tracking host sources, may provide insights into how CI inhabitants may be exposed to fecal pathogens. Fecal pathogen presence and indicator bacteria levels were ascertained for multiple sample types in upper CI, including wastewater effluent and paired surface water and sediment samples from urban and rural rivers. Pathogen testing included *Salmonella* spp., *Vibrio* spp., *Cryptosporidium* spp., *Giardia* spp., and norovirus, while indicator bacteria testing included fecal coliforms, *Enterococcus*, and the alternative indicator bacteria *Bacteroidales* and *Catelicoccus* that additionally provide insight into fecal sources. Multivariate analysis was used to assess the association of environmental factors with the presence of fecal pathogens at each site. Preliminary results revealed the presence of human, dog and bird fecal sources at several sites, as well as multiple fecal indicator bacteria. Study findings will inform stakeholders and local communities regarding the host sources, distribution of fecal pathogens, and relative utility of indicator bacteria for monitoring water quality at the land-sea interface.

**Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Statistical Design, Field Studies, Indices, and Analytical Parameters**

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ICIEMAP includes a core set of collections made in 2008 and 2009 of benthic contaminants (metals, hydrocarbons, and persistent organic pollutants), benthic species composition and abundance, oceanographic CTD profiles and water quality parameters, and sediment grain size and total organic carbon. The methods used to define the sampling framework followed national Environmental Monitoring and Assessment Program (EMAP) protocols, relying on a probabilistic, stratified-random sampling design and a target population of all marine waters within Cook Inlet. Sample locations were distributed across and randomly selected within pre-selected strata, and the sampling frame allowed for statistical comparisons of Cook Inlet background, oil industry operations area, and produced water mixing zones. The sampling frame defined 65 base sites throughout Cook Inlet, allowing for interpretation of Cook Inlet data within the context of a larger Alaska EMAP program conducted in south central Alaska bays and estuaries. In a nested study design, water column samples were collected and analyzed to assess the fate of metal and hydrocarbon contaminants from produced water discharges. Water samples were collected from 18 rivers discharging to Cook Inlet during spring and late summer and a transport study was conducted to follow the effluent plume from the produced water discharge pipe that accounts for over 96% of produced water discharged to Cook Inlet. None of the randomly selected sampling locations were in Kachemak Bay, but a separate study that focused on that region was integrated into the overall sampling plan.

**Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): A Collaboration of Four Inlet Contaminant Studies**

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In 2008 and 2009, a unique partnership was developed to coordinate four separate Cook Inlet contaminant studies into the ICIEMAP. Field sampling and laboratory analyses were coordinated to leverage costs and resources and to share analytical results while still meeting the goals of our four unique initiatives. Components of ICIEMAP included: (1) a Cook Inlet area-wide study based on the national Environmental Monitoring and Assessment Program to measure indicators of water column and benthic health in Cook Inlet, including specific oil industry operation areas, (2) a produced water discharge study designed to fulfill the requirements of an EPA Cook Inlet Oil and Gas National Pollutant Discharge Elimination System (NPDES) Permit that required assessment of the fate and transport of hydrocarbons from large volume discharges of oil industry produced water, (3) a NOAA National Status & Trends bioeffects study at a series of deep water stations in Kachemak Bay, and (4) a riverine background study to assess metals and hydrocarbons in rivers that discharge into Cook Inlet. A very large dataset of biological and chemical parameters was compiled through ICIEMAP to provide a more comprehensive context for interpretation of current and future datasets than would have been provided by any of the individual studies. A description of the complex study design and sampling that occurred at more than 80 study sites will be provided, along with brief summaries of individual study components that are described in more detail in associated ICIEMAP posters.

**Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Distribution Patterns and Sources for Organic Contaminants**

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The goals of the organic chemistry component of ICIEMAP were to investigate hydrocarbons and Persistent Organic Pollutants (POPs) in Cook Inlet and their likely sources with a focus on determining concentrations, transport, and fate of produced water (PW) hydrocarbons. Sediments were analyzed for saturated and aromatic hydrocarbons, POPs, grain size, and total organic carbon (TOC). River water, PW and Cook Inlet water were analyzed for aromatic hydrocarbons. Detectable levels of DDTs, chlordanes, and PCBs were measured at a number of sites. The highest concentrations were in Kachemak Bay, although at levels 1-2 orders of magnitude less than established sediment quality guidelines. Summary statistics by area indicated low concentrations of saturated hydrocarbons (n-C10 through n-C34-alkanes plus pristine and phytane) in all areas. Sediment concentrations of polynuclear aromatic hydrocarbons (PAH; 51 individual parent and alkyl homologues and 5 individual alkyl isomers) were low throughout the study area with a grand mean of  $90 \pm 82$  ng/g. The highest concentrations were found in Kachemak Bay; however, an ANOVA using TOC- and grain size-normalized data indicated no statistical differences between areas. Hydrocarbon fingerprinting showed no sediment accumulation of Cook Inlet crude oil in the study area. PAHs in the water column were all lower than water quality standards and the PAH and BTEX measured in PW showed that BTEX drives mixing zone requirements. Several elevated BTEX concentrations were obtained in the oil industry area; however, their locations relative to prevailing currents do not indicate a PW source and additional sampling is planned.

**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) is a dynamic ecosystem which supports important fisheries and the communities dependent on them. Understanding recruitment is central to rational fishery and ecosystem planning. Recruitment is thought 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 principally 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 plan to use 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, walleye pollock, Pacific cod, Pacific ocean perch, and sablefish. Conceptual frameworks for the five IBMs are presented. The models will serve as a tool to integrate other components of NPRB's GOA-IERP that are oriented more toward field studies: the Upper Trophic Level, the Middle Trophic Level, and the Lower Trophic Level projects. Field results from these projects will be used to develop, initialize and validate the models.

**Between Pacific Tides: Revisiting Historical Surveys of Sitka through Ricketts, Calvin and Ahlgren**

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In 2011, the Sitka Sound Science Center began a community involvement project re-establishing intertidal surveys from 1932 and 1996 in Sitka Sound. The authors of *Between Pacific Tides*, Jack Calvin and Edward Ricketts, 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. Today this marine environment may reflect significant changes partly because sea otters are now common and WWII development left a mark. Dr. Molly Ahlgren, in 1996, began using the only intact intertidal area in downtown Sitka as an outdoor classroom, conducting intertidal surveys until her untimely death in 2004. This NPRB funded project to-date has 1) selected and documented the historic survey sites to be used, 2) evaluated the suitability of the historical data to evaluate long-term influences, 3) evaluated the appropriate methods to connect historical surveys (with no written protocol) with current scientific methods using the 2004 Coastal Biodiversity MARINE Protocols developed by UC Santa Cruz and 4) identified the steps necessary to best engage the community in current scientific practices and inform Sitkans of the importance Sitka has and continues to play in the history and study of marine biology in the marine ecosystem dynamics North Pacific.

**Integrated Cook Inlet Environmental Monitoring and Assessment Program (ICIEMAP): Distribution Patterns and Sources for Trace Metals**

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The metals portion of the ICIEMAP investigated the present status of any metal contamination as well as likely sources of natural and anthropogenic metals to the inlet. Concentrations of Ba, Cd, Cr, Cu, Ni, Pb and Zn were at background for all 55 sediment samples. Arsenic, Mn and Se values were above background at 3-4 locations due to natural diagenetic processes. Sediment Ag concentrations were above background near the Susitna and Kasilof rivers. Mercury values were elevated at 10 locations, including 5 sites in Kachemak Bay. All sediment values were below sediment quality criteria for those metals with reliable criteria, namely Ag, Cd, Hg, Pb and Zn. Dissolved metals in saltwater were at background with the exception of elevated dissolved Pb at a few near-river mouth sites. Concentrations of dissolved Ag, Cd, Cu, Ni, Pb, Se and Zn in produced water were equal to or lower than values for ambient seawater in Cook Inlet. All metals in produced water from Cook Inlet were low relative to typical produced water because the salinity and dissolved organic matter content were low. In river water, only concentrations of dissolved Pb and Hg seemed to be elevated above expected values, an observation found at about half the locations. Overall, metals in Cook Inlet were predominantly at background values with no detectable metal enrichment from discharges of produced water. Concentrations of metals in rivers were quite variable with inputs that reflected different geologic regimes around the Inlet, as well as potential anthropogenic sources.

**The End of Life as We Know It...and Other Problems with Hatcheries**

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The put-and-take business of "ocean ranching" of hatchery salmon extracts nutrients from the ocean and lowers the carrying capacity for all biota. A sizeable proportion of wild salmon runs spawn and die in thousands of watersheds which helps maintain the natural marine-terrestrial-marine nutrient cycle. In contrast, nearly all salmon returning to hatcheries and remote release sites are caught (and should be) and their tons of marine-derived nutrients are removed from the nutrient cycle. Thus, not only are wild fish and shellfish facing direct competition from five billion-plus hatchery salmon now released into the North Pacific each year but the ocean's productivity is declining from the nutrient mining inherent with these industrial-scale ocean ranching hatchery programs. Of all the anthropogenic and climate challenges we face, at least we have complete control over this one.

**Southeast Alaska Long-term Seawater Monitoring Program for Ocean Acidification**

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The Southeast Alaska Monitoring Program began as an ecosystem approach to study the seawater located in the inside passage along the Gulf of Alaska. The program's purpose was to develop baseline data and determine trends in a variety of ocean acidification parameters. Monitoring sites have been chosen in the local area of Juneau, Alaska, and have recently extended to Sitka and Prince William Sound. At each site, seawater is collected every month at the surface and varying depths to capture the full seawater profile. Monitoring parameters for ocean acidification have included dissolved inorganic carbon, alkalinity, pH, salinity, and temperature. After 2 years of data collection, the seawater in Juneau is showing distinctly different trends than those found in the open ocean waters of the Pacific Ocean or Gulf of Alaska. The amplitude of seasonal pH, total dissolved inorganic carbon (TC), and total alkalinity (TA) cycles in these inside waters is about 10 times greater than seasonal variation reported in open ocean water. Seasonally, pH cycles with an amplitude of about 0.6 pH units in local surface water (0 to 7 m) and about 0.2 units at 23 m. The pH maxima are in spring or summer and minima are in winter. The TC and TA cycles are opposite the pH cycle, with peaks and troughs about 180° out of phase. Seasonal variation in TC and TA cycles approaches 1000  $\mu\text{mole/kg}$  seawater. These seasonal fluctuations in ocean acidification parameters have implications for resident biota. Have these organisms adapted to broadly variable conditions or have they developed behavioral strategies to avoid seasonal stresses? What is causing the high amplitude in the ocean acidification parameters of Juneau seawater-freshwater influence from our rivers, glaciers, and rain or due to seasonal phytoplankton blooms? As the monitoring program continues, these and other questions are being addressed and giving us insight into understanding the role ocean acidification will play in the seawater of Southeast Alaska.

### **Growing a Sustainable Community Monitoring Program**

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For the past six years the Kachemak Bay Research Reserve has maintained two community monitoring programs: Monitoring for European Green Crab and Harmful Algal Bloom Monitoring. The objectives of these programs are early detection of invasive or harmful species, public education about potential harmful species, and refinement of our native species lists and natural baseline information. We have learned some lessons and gained some tools as our programs have grown to be productive and sustainable. When we ask our volunteers what about our monitoring program appeals to them, they frequently state that they enjoy continuing to learn new things and like to gain knowledge of their own "backyard." Contacting volunteers throughout the monitoring season by sending out results and exciting news keeps them engaged, and receiving a summary of each monitoring program once a year allows volunteers to compare other areas with their own. An additional benefit to working with monitors is that they take outreach messages from our programs into the community as they interact with their family, coworkers and friends. Kachemak Bay Research Reserve has found success using these and other techniques and methods while we maintain a pool of over 30 monitoring volunteers. We appreciate being able to work with these conscientious citizens of Kachemak Bay.

### **Generating an Oral History of Habitat Use by Cook Inlet Belugas in Waters of the Kenai Peninsula Borough**

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In May, 2011, staff and volunteers at the Alaska SeaLife Center commenced a project to document observations of habitat use by Cook Inlet Beluga whales (CIBW). The overall goal of this project was to develop a record of historical distribution and habitat use by CIBW in waters adjacent to the current boundaries of the Kenai Peninsula Borough prior to 1994. Following extensive newspaper and community advertising inviting the public to share their stories about CIBW, we have completed >100 interviews. Those interviews have been supplemented by library and archive research and by analysis of all scientific survey data since 1975. Our preliminary research suggests that there is a potentially significant body of oral history and even photographic information about CIBWs that has not yet been contributed to the CIBW recovery process. We are also aware that there was little follow up to key observations that were reported previously which may have yielded key insights. For example, many respondents have reported a significant decline in seasonal use of the middle stages of the Kenai River by CIBW. The results of the survey will be available online and in an educational exhibit to be installed at the Alaska SeaLife Center in early 2012.

### **Assessment of Contaminant Levels in Subsistence Shellfish from Resurrection Bay, AK: an Interspecies Comparison**

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Subsistence activities are a large part of the traditional culture in Alaska. But, as acknowledged by Wolfe, (1996), subsistence food contamination is a health concern in rural Alaska. There is no systematic wild food testing in Alaska, and communities that rely on subsistence foods have minimal information about the safety of their harvest. This project assessed the overall health of three shellfish species (littleneck clams, mussels and cockles). The shellfish were collected from a traditional harvest area in Resurrection Bay and analyzed for contaminants and occurrences of pathogens and diseases. Contaminants analyzed include PAHs, DDTs, PCBs, other pesticides and heavy metals. Maximum values for mercury were found in blue mussels, while chromium and nickel were relatively elevated in cockles. Parasites such as gill ciliates, and gut rickettsia were prevalent in clam and mussels, and digestive tubule atrophy was the most prevalent disease with 96% to 100% occurrence in all three shellfish. Histological conditions such as tissue inflammations were detected, but at relatively low levels. Relative to FDA action levels, contaminant body burdens were fairly low. Overall the conditions of the shellfish did not appear to be a threat to the health of the shellfish or to people that consumes them. Interspecies concentration factors (ICFs) that relate chemical concentrations in mussels to those in subsistence shellfish, were also determined. The intent is to use the mussels as surrogates thereby eliminating the need to monitor all species used for subsistence.

### **Public Perception of Climate Change and Its Impact on Alaska's Marine Ecosystems**

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Understanding public attitudes towards climate change is critical to promoting climate and marine literacy. Over the past three years, the Alaska SeaLife Center (ASLC) has begun to document public perceptions of climate change, surveying different population segments in Alaska. The 2011 survey involved 211 respondents drawn from four populations: ASLC staff, ASLC visitors, Seward residents and Anchorage residents. The survey was based on Yale University's Project on Climate Change Communication, but with a specific focus on climate impacts on Alaska's marine ecosystems. The results indicate that 78% of the public perceive scientists as the most trusted source for information relating to climate change. In most cases, the public does not appear to understand how climate change is impacting Alaska, specifically marine wildlife. A majority of people, 69%, are concerned that climate change will impact their life, but lack adequate education relating to its impacts. This indicates that climate change science has not been effectively communicated to the public in Alaska. The positive news is that 82% of respondents wish to learn more and are open to new education opportunities. These results will be used to track the effectiveness of ongoing climate change education efforts. Results will assist educators and scientists in improving climate education programs, practices and materials.

**Alaska Clean Harbors: Reducing Pollution at Alaska's Harbors and Marinas**

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Alaska's vast coastline and rich marine systems attract hundreds of thousands of recreational and commercial boaters each year, and these magnificent resources generate significant revenues for local communities and small businesses. But Alaska's harbors and boat launches also pose some of the most vexing pollution and environmental protection issues facing the state. Boat-based lubricants, fuels, sewage, batteries and plastics can pollute local waters, contaminate fish and shellfish, and entangle marine life. At the same time, our harbors and launches also provide incredible opportunities to educate user groups, change behaviors and reward pollution prevention practices. Alaska Clean Harbors is a voluntary, non-regulatory certification program that works with Alaskan harbors and marinas to reduce pollution through the implementation of best management practices. In late-2011 the Homer Harbor submitted an application for certification, and the City of Seward and Burkesshore Marine (in Big Lake, Alaska) signed Clean Harbor pledges to work towards certification. Educating harbor operators and boaters on the whys and hows of protecting the marine environment is a critical component of certification as an Alaska Clean Harbor. Inletkeeper works with an advisory committee and other researchers and technical experts to guide these efforts. Research on boat-based pollutants and their effects on marine life help to illustrate the need for pollution prevention improvement in our harbors and by our recreational, sport, and commercial fleets.

**Socioeconomic Assessment of Major Oil Spill Litigation and Settlement**

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Alaskans continue to be affected by the Exxon Valdez oil spill of 1989. Indeed, the 22nd application for distribution of punitive damage awards suggests that final resolution may not occur until 2013. Planners and policy-makers should therefore envision major oil spill events not only in terms of initial and near-term human and environmental impacts, but also in relation to protracted litigation and settlement. This presentation describes a study sponsored by the Bureau of Ocean Energy Management (BOEM) to examine major oil spill litigation and settlement over the long-term as exemplified especially by *Grant Baker et al. v. Exxon Mobil Corporation* and its effects on claimants and communities of Kodiak Island. Extensive pre- and post-settlement research was conducted to examine whether disbursement of punitive damages award monies would: (1) change the nature of participation in Kodiak's commercial fishing industry; (2) influence participation in local subsistence fishing and hunting activities; (3) affect demographic conditions in the Kodiak study communities, and (4) affect existing sociopolitical relationships within and across residents and groups of residents in the study region. Although the total punitive damages award advanced by the Ninth Circuit Court of Appeals was significantly reduced by the U.S. Supreme Court in 2008, the outcome of the case generated a variety of measurable social and economic impacts on Kodiak Island. This presentation describes select results of the study and outlines policy recommendations that could serve to minimize deleterious long-term human effects of major oil spills.

**A Collaboration for Oil Spill Planning and Response: Demonstration of the Cook Inlet Response Tool**

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The Cook Inlet Regional Citizens' Advisory Council (CIRCAC), the Alaska Ocean Observing System (AOOS), and the National Oceanic and Atmospheric Administration (NOAA) are collaborating on the development of the Cook Inlet Response Tool (CIRT). The overarching goal of this particular collaboration is to develop and demonstrate a next generation oil spill response application that combines GIS spatial data layers, AOOS real time observations and model nowcast/forecasts for winds, waves, and ocean circulation, and a ShoreZone video imagery viewer. This demonstration project is focusing on Cook Inlet because many of the needed datasets are mature and the area is relatively small and tractable. Although CIRT will provide the ability to visualize disparate datasets for many applications, a demonstration of the tool will focus on datasets important to oil spill planning and response. Included will be coastal community oil spill resources and infrastructure, background contaminants, habitat and resource information from Environmental Sensitivity Index (ESI) databases, biophysical habitat data from the Alaska ShoreZone program, and other resource data important for oil spill response decisions. Access to real-time ocean and atmospheric observations will be demonstrated along with integration of ocean and atmospheric model results. The CIRT application will be scalable so that other areas in Alaska and the nation will benefit and will integrate with NOAA's Emergency Response Management Application (ERMA), which will be utilized for Arctic oil spill response planning.

## **Preparation of Monoclonal Antibodies to Saxitoxins for use in PSP Detection**

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Paralytic shellfish poisoning (PSP) represents a deadly public health threat in Alaska. PSP is caused by consumption of shellfish contaminated with saxitoxins (STX), a family of neurotoxins produced by microalgae in the genus *Alexandrium*. Current methods for monitoring PSP toxins in Alaska are both costly and time consuming. A rapid test kit that can be used locally to monitor saxitoxins levels would therefore be of great benefit. Rapid test kits for environmental toxins like STX can typically use antibody based enzyme-linked immunoassay (ELISAs) technology. The challenge in developing an accurate ELISA test kit for STX is that there are over 50 different structural forms (congeners) of STX which vary in toxicity. No single antibody is likely to detect all of the various toxic congeners. Instead, a suite of antibodies specific to different congener subgroups will be required. Currently, we are developing such a suite of subgroup specific monoclonal antibodies. Our approach is to construct a several STX immunogens having different structures that mimic the major classes of STX. This poster reports our strategy to obtain a panel of monoclonal antibodies capable of recognizing a range of saxitoxin congeners, preliminary results showing an immune response to our first STX immunogen, and results of initial fusions showing the sensitivity and specificity of anti-STX monoclonal antibodies developed in the first phase of this project.

## **Cultural Models of Copper River Salmon Biology**

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This paper compares cultural models of salmon fisheries among local and traditional knowledge (LTK) holders and fishery biologists in the Copper River region of Alaska. Previous studies demonstrated indigenous Ahtna and fishery managers have different perspectives on the long term sustainability of the region's fisheries. Using consensus analysis, a consortium of Alaska researchers measured agreement between and among Ahtna, commercial fishers, and fishery managers on salmon stock structure, movement, abundance, stock condition, and management. Results revealed agreement within each group individually and lack of agreement in the group as a whole. Responses from all three groups reveal sensitivity to matters of abundance, particularly those from the Ahtna, who share a perception about diminishing abundance. Fishery managers were the most cohesive of the three groups in their shared views.

### **High-Resolution Monthly Precipitation and Temperature Grids for Alaska, USA: A Resource for Hydrological Studies**

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Estimates of coastal freshwater discharge into the Gulf of Alaska are necessary for a variety of stakeholders. Freshwater fluxes play a role in controlling nearshore salinity and temperature fields and resultant circulations. These abiotic parameters, in turn, are part of the foundation for understanding observed biological patterns. Discharge estimates require high-resolution meteorological information such as precipitation and temperature as input. High-resolution grids of these parameters on a monthly time scale were produced during the first year of an NPRB-funded study of the discharge into the Gulf. Extensive weather station time-series data were synthesized with existing climatological norms to produce these grids. Generated results over a 50 year period demonstrated strong annual and inter-annual variability in conditions. The precipitation estimates were overlaid on the three principal watersheds of Alaska (Gulf, Bering Sea, Arctic Ocean) in order to provide an 'upper bound' on the water available for runoff into those water bodies. The results were favorably compared to other recent estimates of precipitation and temperature. At the outset of the second year of the project, these weather grids are being used to estimate discharge from delineated watersheds comprising the entire Gulf of Alaska drainage. Rainfall-runoff relations will be calibrated using gaged basins in the drainage and the results will be applied to the remaining ungaged basins in the drainage.

### **The Effects of Ocean Acidification on Maternal Condition and Reproductive Success and Larval Condition and Survival of Tanner Crabs, *Chionoecetes bairdi***

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Increased atmospheric CO<sub>2</sub> concentrations have caused a corresponding increase in the oceanic CO<sub>2</sub> concentrations which has led to a change in the oceanic carbonate chemistry and a decrease in the pH. Calcifying organisms may be particularly affected as the reduction in pH makes it more difficult to excrete and sustain a calcified shell or exoskeleton. We examined the effects of ocean acidification on Tanner crab, *Chionoecetes bairdi*. We hypothesized that ocean acidification will result in decreased fecundity, embryo viability and condition, and larval survival, mass, and condition. We also hypothesized that ocean acidification will increase embryo development time, alter larval morphology, and lead to reduced shell calcification. In April 2011, ovigerous Tanner crab females with late stage eyed embryos were collected from Chiniak Bay, Kodiak. To assess the effects of increased CO<sub>2</sub> concentrations on crab embryology, ovigerous females were placed into separate containers with treated (pH = 7.5 or 7.8) or ambient (pH=8.0) seawater with 1 L/min flow-through and constant temperature. Alkalinity, pH, and dissolved inorganic carbon were monitored daily and a sample of embryos was digitally imaged to assess development. To assess the effects of increased pCO<sub>2</sub> on larval crab survival using the same three pH levels at constant temperature, larvae were placed into 1 L beakers and monitored for survival, molting, and changes in morphology. Initial results indicate decreased larval survival with lower pH. Upon project completion this study will provide an initial understanding of physiological impacts ocean acidification may have on North Pacific crab species.

### **Seasonal Exchange between Prince William Sound and the Gulf of Alaska**

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Prince William Sound (PWS) is a semi-enclosed fjord-like embayment with two significant passages connecting it to the Gulf of Alaska. The water exchange through these passages impacts the local circulation and ecology. We summarize new results from a 5-year mooring program designed to quantify the exchange. The current observationally-based wisdom on seasonal exchange is that water always enters through Hinchinbrook Entrance (HE) and exits through Montague Strait (MS). Maximum depth-integrated transport occurs in winter. The transport is typically layered, and there is considerable variability on shorter time scales. According to our new results, this "flow-through" picture is only approximately correct. In summer, the transport through HE is small and equally likely to be directed into or out of PWS. In winter, the transport at HE is always inward, and larger than in summer (but smaller than previous estimates). The depth-integrated transport at each entrance correlates relatively well with along-shore winds on the shelf. In winter, strong easterlies drive water northward into HE, which is approximately balanced by outflow through MS. In summer, the easterlies weaken, which reduces the surface inflow through HE, allowing deep water from below the shelf to flood into PWS. We expect these results to be more accurate than previous studies because they are based on data from two moorings per passage instead of one. However, hydrographic transects and the observed imbalance between transport through HE and MS suggest that higher spatial resolution is necessary to accurately estimate transport.

### **Sources and Patterns of Interannual Oceanic Variability of in the Gulf of Alaska**

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The Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP) investigates the physical and biological mechanisms that determine the survival of juvenile groundfishes in the eastern and western Gulf of Alaska. As one element of this program, we seek to identify significant regional-scale modes of interannual oceanographic variability in the GOA, as well as their large-scale atmospheric and oceanic drivers. Empirical Orthogonal Function (EOF) analyses of biologically relevant physical properties (along- and cross-shelf velocities at the shelf break, Eddy Kinetic Energy, spring and fall stratification, SST), derived from a 40-year hindcast of the GOA, reveal spatial modes with time amplitude related to large-scale atmospheric and oceanic indices (the multivariate El Niño index, the Pacific Decadal Oscillation and the North Pacific Gyre Oscillation). A multivariate EOF analysis further suggests how the various forcing factors couple to the regional oceanic response. These analyses will help us to identify representative years for intensive, fine-scale process modeling in GOAIERP.

### **Oceanographic Variability in Kachemak Bay, Alaska**

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Detailed information on temporal and spatial variability of near-shore oceanographic conditions in Kachemak Bay Alaska is needed to assess the response of these subarctic estuarine waters to seasonal and inter-annual changes in temperature, freshwater input and ocean circulation. Such measurements are critical to understanding how climate change may affect Gulf of Alaska coastal ecosystems, to assess environmental triggers for harmful algal blooms, and to support studies on the coastal effects of ocean acidification. Additionally, the oceanographic information is being used for development and validation of a NOAA National Ocean Service ocean circulation model for Cook Inlet. Oceanographic variability is assessed using 2004-2011 data from Kachemak Bay National Estuarine Research Reserve water quality monitoring stations at the Homer and Seldovia harbors, vertical water column profile data from ongoing small-boat transects with a Sea Bird Electronics SEACAT 19plus conductivity-temperature-depth (CTD) profiler, and from temperature sensors deployed at additional shoreline stations. Temporal differences are consistently more significant than spatial differences between stations. Significant inter-annual variability includes differences in mean monthly water temperatures of up to 6C in winter and 5C in summer. Upper water column density decreases from May through September and vertical water column stratification reaches a maximum in mid-summer, although inter-annual differences are observed in both the timing and relative degree of stratification. A combination of temperature thresholds and degree of stratification is assessed as an index for potential onset of harmful algal blooms from the phytoplankton species that cause paralytic shellfish poisoning.

### **Alongshelf Differences in Hydrography and Currents in the Gulf of Alaska**

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As part of the GOA-IERP the R/V Thompson conducted an ecosystem survey from May 3-18, 2011 which began before the onset of the spring bloom in the coastal area between 54° and 60°N. Physical and chemical data included: temperature, salinity, PAR, fluorescence, and concentrations of dissolved oxygen, nutrients and chlorophyll concentrations. Iron data was collected both from surface transects and at selected stations. During the initial survey water temperatures on the shelf were uniformly ~6°C, but coastal surface salinities were progressively fresher from south to north. Surface nutrient were relatively constant during the initial survey with ~11umol/kg NO<sub>3</sub> at the surface. By May15-18, NO<sub>3</sub> had been drawn down to ~6umol/kg. True-color satellite images show areas of recurrent production north and west of Cross Sound and west of the southern tip of Baranof Island throughout the summer. Sources of nutrients for this production are likely Cross Sound and Chatham Strait. As part of this program, 8 moorings and six drifters were deployed in Southeast Alaska and another 8 moorings at the head of the GOA. Drifters illustrated that cross-shelf flow is common on the narrow southeastern GOA shelf and is more affected by canyons on the broader shelves to the north. Cross Sound is dominated by estuarine circulation, with inflow on the south and outflow of vertically mixed waters on the north. Shelf currents move northward along the coast with interruptions at Cross Sound, off Yakutat and at Kayak Island.

**The Impacts of Climate Induced Deglaciation on Ocean Acidification in Glacier Bay, Alaska: Insights from a New Ocean Time-Series**

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Numerous studies have shown that the intrusion of anthropogenic CO<sub>2</sub> into the ocean has created an acidification phenomenon. However, the intrusion of atmospheric CO<sub>2</sub> is not the only climate-induced factor leading to a reduction in pH and the suppression of carbonate mineral saturation states (Î©). Glacier Bay, located along the southeastern shelf of the Gulf of Alaska (GOA), is a young silled fjord that has experienced one of the most rapid deglaciations on record over the last 225 years. This deluge of low-alkalinity glacial runoff is expected to reduce the buffering capacity of surface waters and enhance the vulnerability of this estuary, as well as the adjacent GOA shelf, to further decreases in pH. Here, we demonstrate the impact of glacial discharge on Î© within Glacier Bay by presenting data from the first ever ocean time-series in a glaciated estuarine system. Monthly sampling of the carbonate system illustrates the spatial and temporal variability of Î© and the extent of ocean acidification throughout the water column from the headwaters of Glacier Bay to the marine interface in Icy Strait.

**Nutrient Dynamics in a Productive Downwelling System: The Coastal Gulf of Alaska 1998-2010**

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The coastal Gulf of Alaska (GOA) is a highly productive region characterized by massive phytoplankton blooms supporting a rich ecosystem and commercially important fisheries. The Seward Line oceanographic transect in the GOA has been occupied multiple times per year from 1998-2004 and twice per year from 2005-2010+ as part of GLOBEC and NPRB research programs. Nutrient data from this time series demonstrate a strong seasonal pattern with significant interannual variability. In this downwelling system, macronutrients are replenished to the surface waters by winter overturning and vertical mixing events throughout the growing season.

Preliminary findings suggest that primary production at near-shore stations within the Alaska Coastal Current (ACC) is nitrate-limited in contrast with HNLC zones in the central GOA. The concentration of nitrate available to surface waters each spring is a controlling factor in the strength and duration of the spring bloom, which in turn effects all levels of this bottom-up controlled ecosystem. A trend toward freshening of the surface layer due to increased glacial melt in this subarctic region may be driving earlier and stronger stratification. Differences and similarities between the nutricline and pycnocline are discussed. Correlation with other physical parameters such as the ENSO index and the downwelling index may help explain interannual variability in the spring nitrate level.

### **Seasonal Cycle Simulation for Prince William Sound, Alaska**

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A three-domain nested model is used to simulate the oceanic seasonal cycle of Prince William Sound in order to understand larval transport for fisheries management. The model, which is configured from the Regional Ocean Modeling System (ROMS), has 40 levels in the vertical direction and horizontal resolutions of 10km, 3km and 1km for its three nested domains, respectively. Besides the ordinary atmospheric forcing fields such as wind stress, heat flux, and precipitation, the model is also forced by freshwater discharge and tides. With all these forcing fields, the seasonal cycle of Prince William Sound for 2004 is simulated. The seasonal freshening of Prince William Sound including a variation in the surface salinity of around 7psu can be reproduced. The seasonal cycle in the sea surface temperature of around 10C is also realistically simulated. The prevailing summer circulation pattern of a cyclonic gyre in the central Sound, as observed by the high-frequency coastal radar, is also reproduced in the seasonal cycle simulation. Numerical experiments are designed to analyze the influence of freshwater discharge and tides on the seasonal cycle of Prince William Sound. Though the influence of freshwater discharge and tidal forcing is different over time, for annual averaged state, including freshwater discharge and tides tends to generate a cyclonic gyre in the central Sound. Our results also raise the challenging issues of validating the regional model output with sparse observations, in particular, for circulation and freshwater discharge.

### **Over a Decade of Monitoring Lower Trophic Levels on the Alaskan Shelf**

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The Continuous Plankton Recorder was first routinely deployed in 2000 and since then has collected seasonal data each year on lower trophic levels across the Alaskan Shelf and into the open Gulf of Alaska. This poster describes the timeseries and interannual variability in the larger hard-shelled phytoplankton and the mesozooplankton taxa sampled by the CPR. Lower trophic levels respond strongly to ocean climate, which has been quite variable over the course of the last decade leading to changes in community composition and seasonal timing. This underscores the need to monitor the plankton to understand how this variability is transferred to higher trophic levels.

### **LarvaMap – A Web Based Larval Behavior Model for Prince William Sound and High Latitude Pacific**

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Understanding larval transport and survival is critical to effective fisheries management. Larval transport models aid fisheries, habitat and marine protected area decision makers in understanding how ocean circulation and larval behavior affect survival. With support from OSRI, we are continuing development of a community larval transport model, LarvaMap, a 3D web-based larval fish and invertebrate transport model connected to ROMS circulation fields for the northeast Pacific. Within this project, LarvaMap is being enhanced by constructing two larval organisms: Herring and Dungeness crab. Library organisms will be available for use or modification. The historical time-series of the Regional Ocean Modeling System (ROMS) model time-series data for Prince William Sound (PWS) has been expanded from 2004-2010. As new species are developed, we plan to construct a framework for creating new organisms for numerical simulation.

LarvaMap can use any circulation dataset formatted using the network Common Data Format for Climate and Forecast (NetCDF CF) available through a Thematic Realtime Environmental Distributed Data Services (THREDDS) data server (TDS). Both NetCDF and TDS are oceanographic community standards. LarvaMap output can be viewed in combination with field data and circulation model results using HabitatSpace, a 4D data analysis tool previously developed by members of this team for the NOAA Alaska Fisheries Science Center. Our ultimate goal is to develop a web-based larval transport tool that can be used for fisheries managers, researchers and educators. With remote access to circulation fields, the model will be easily relocatable to new areas and species.

### **State of the Sound: Recent Oceanographic Conditions in Prince William Sound**

**Rob William Campbell**, rcampbell@pwssc.org, Prince William Sound Science Center

Regular (~monthly) oceanographic surveys have been conducted since November 2009 as part of the Exxon Valdez Oil Spill Trustee Council supported Prince William Sound Herring Survey program. Those surveys visit 12 stations located within herring nursery bays (Eaglek, Simpson, Whale and Zaikof Bays); the main entrances to PWS (Hinchinbrook Entrance and Montague Strait); and in central PWS. Each station consists of a CTD cast, water samples for nutrients and phytoplankton, and a zooplankton tow. As might be expected, the heads of the bays warmed more quickly in spring, but that did not lead to an earlier onset of the spring bloom: open water stations showed increases in productivity prior to the heads of the bays. Total productivity varied between locations, and did not vary in a consistent way. Clustering analysis of plankton taxa broke down fairly well into geographic areas, with an open water cluster and inshore cluster; bays on the eastern side of PWS tended to occur in clusters distinct from the western side. Indicator species analysis showed that the taxa characteristic of the different groups was generally not unique. Rather, the relative importance of several common taxa (including copepods, larvaceans, chaetognaths and larval euphausiids) differed among the different clusters. Analysis of the hydrography at the different stations suggests that the differences between the groups are partially attributable to transport patterns (i.e. transport of oceanic taxa into the Sound). Local production was also potentially important, as evidenced by meroplanktonic taxa, such as barnacle larvae, particularly in the bays.

### **Processes Controlling On-Shelf Transport of *Neocalanus* Populations in the Northern Gulf of Alaska**

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**Georgina Gibson**, gagibson@alaska.edu, University of Alaska

*Neocalanus* are large high-energy crustaceans important to the diets of a variety of commercial fish during their early life-history stages. However, *Neocalanus* overwinter off the shelf break in habitats geographically removed from fish stocks on the continental shelves. Using a three dimensional circulation model coupled to an individual based float tracking model, we explored the climate-driven processes transporting *Neocalanus* onto the Gulf of Alaska shelf and into fjords and near-shore habitats. Results indicate that *Neocalanus* originating near the shelf break as far southeast as Dixon Entrance can be transported westward along the shelf and enter Prince William Sound (PWS) and Lower Cook Inlet (LCI) within 2-4 months. No floats released west of Hinchinbrook Entrance entered PWS, no floats released west of Kennedy Entrance entered LCI and Shelikof Strait. Winds had the greatest influence on transport of floats in the upper 20 m. Increasing or decreasing winds by 20% over CORE values significantly increase or decrease (respectively) transport into PWS and LCI. Runoff and temperature were of secondary importance. Preliminary results indicate that forcing simulations with high-resolution wind data caused significantly more floats originating off southeast Alaska to enter PWS. These simulations predict that climate change resulting in elevated winds will increase transport of ocean water masses with their resident zooplankton assemblages into the fjords and near-shore habitats, potentially displacing resident zooplankton and impacting growth and survival of commercially important fish species which use these habitats as nursery areas.

### **Effects of Ocean Acidification on Larval Development in Alaskan Crabs**

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The goal of this study is to measure the effects of ocean acidification on larval development in Tanner crabs, *Chionoecetes bairdi*, and Dungeness crabs, *Metacarcinus magister*, in Alaska. A climate-driven challenge to marine populations is the expected decrease of up to 0.4 pH units in high-latitude waters of North America in the next century. Such a decrease could prove to be detrimental to Alaskan crabs by causing elevated rates of mortality and abnormal development in early life stages. In coastal Alaska, several Tanner and Dungeness 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. Here, it is hypothesized that increasing acidity will cause decreased survival, morphometric deformities and decreased calcification rates in larval Tanner and Dungeness crabs. 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 monitored at frequent intervals for survival, morphometrics and calcification rate of the exoskeleton during the first zoeal stage.

### **Decadal Estimates of Productivity by Pteropods and Larvaceans in the Coastal Gulf of Alaska**

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The thecosome pteropod, *Limacina helicina*, and larvaceans have been shown to be dominant components of the juvenile pink salmon diet. These gelatinous plankton are understudied due to their fragile structure that is easily damaged during collections. Preliminary estimates of their composition, abundance and biomass generated along the Seward Line in the Gulf of Alaska show high variability, partially due to the initial focus on the more dominant crustacean zooplankton. We present a refinement of these preliminary numbers and are extending the length of observation to over a decade. To establish productivity, growth rates are being established for the pteropod *L. helicina* by culturing it at 5°C in specialized 20L containers equipped with rotating paddles. By applying these pteropod growth rates, and those projected for larvaceans, to our revised estimates of abundance and biomass, we estimate their potential productivity levels in the Gulf of Alaska. Ultimately, we will explore if these correlate to patterns of pink salmon survival.

**A Broad-Scale Look at Physics through Plankton in the Coastal Gulf of Alaska**

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NPRB's Gulf of Alaska program completed its first field season in 2011, with a series of cruises running from April through October. We describe the activities undertaken by the Lower Trophic Level component, from Southeast Alaska around the shelf to Kodiak, with emphasis on the spring cruises. The 2011 spring bloom was delayed by at least several weeks relative to average timing in the region. In May, temperatures were slightly colder than normal, macronutrient levels were still high, and chlorophyll levels low over most of the region. The phytoplankton community was dominated by cyanobacteria and tiny flagellates, and photosynthetic rates were strongly photo-inhibited at near surface light levels, indicating a recent history of low light exposure. In addition, the shelf was scattered with several large gelatinous zooplankton species (salps and ctenophores) typically associated with warm waters. This suggests significant northward transport of water had occurred over the winter. Preliminary counts of larval fish initially reveal a general absence of walleye pollock and Pacific cod in the study area. Sablefish (*Anoplopoma fimbria*) and rockfish (*Sebastes* spp.) were most abundant over the outer shelf and shelf break with high concentrations of sablefish larvae in the neuston at night. These larval fish patterns will be compared with those observed in the 2010 spring and fall pilot study.

### **Rhodolith Habitat in Prince William Sound**

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Rhodoliths are free-living, calcareous red algae, which are known to be important habitat providers in nearshore waters around the world. In 2006 we reported on the discovery of a rhodolith bed in Prince William Sound, the northern-most rhodolith record in the Eastern Pacific. Here we present a comprehensive description of the community associated with these rhodoliths. The community was highly diverse compared to surrounding similar habitats without rhodoliths. Particularly chitons, bivalves, gastropods and polychaetes contributed to high diversity. Some other taxa such as sipunculids and ophiuroids were highly abundant in these rhodolith habitats. Potential species of commercial interest such as scallops were also common in these habitats.

### **Status of Hard-shell Clam Assemblages in Organized Coarse-Grained Sediments in Western Prince William Sound – A Preliminary Report**

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A 2002 study at 40 coarse-grained beaches in western Prince William Sound indicated that beach washing to clean up oil from EVOS resulted in substantial long-term injury to hard-shell clam assemblages and possibly disturbed the organization of coarse sediments that support these assemblages. Densities of small and adult hard-shell clams averaged 66% lower at washed sites than at oiled-but-unwashed sites. A deductive process led to the hypothesis that reduced organization in the surficial layer of coarse clasts at washed coarse-grained beaches resulted in the observed lagging clam recovery. In 2010, we returned to 39 of these locations to: 1) update clam recovery status; and 2) evaluate whether sediment organization was, indeed, a factor in lagging recovery. The latter required developing an approach for measuring organization in surficial coarse sediments. Preliminary comparisons indicate that bivalve and infaunal assemblages have experienced major declines since 2002. This is particularly notable for littleneck clams, in which small and adult size classes have declined 95%. The 14 % decline in butter clams is far less striking. Preliminary analyses of 2010 data indicate that density of littleneck clams at unwashed sites was 45% lower than at washed sites but 13% higher for butter clams. However, the differences between hard-shell clam density at unwashed and washed sites do not appear significant. It's likely this apparent breakdown in the relationship observed in 2002 is strongly affected by the dramatic decline in clams. A similar decline may be operating in hard-shell clam and infaunal assemblages throughout the northeastern Pacific.

**Hands-on Workshop To Identify Toxic Alexandrium Species Using qPCR Methods**

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You are invited to participate in a hands-on qPCR workshop in Juneau and learn how to identify toxic Alexandrium species which produce the toxins responsible for Paralytic Shellfish Poisoning (PSP). The 1.5 day workshop is intended to build monitoring capacity in Alaska. Any individual with an interest in understanding and monitoring toxic Alexandrium blooms in Alaska including public health officials, resource managers, commercial aquaculturists, academic researchers, environmental NGOs would benefit. The tentative dates for the training are February to March in Juneau. Exact details will be posted on the NPRB web site prior to the annual meeting and on this project poster at the AMSM in January 2012. As part of an NPRB funded project, similar molecular assays have been developed for detecting toxic Alexandrium in Alaskan waters. Having the ability to directly monitor toxic blooms allows identification of key sentinel sites and provides early warning of when increased toxin monitoring is advantageous. This hands-on workshop is intended to provide training on how to process water samples and estimate the abundance of toxic Alexandrium species present using quantitative PCR assays. If you are interested in participating in the winter 2012 workshop in Juneau, please contact Wayne.Litaker@noaa.gov.

**Preliminary Findings on the Effects of Maternal Diets on Egg and Early Larval Development in the California Sea Cucumber (*Parastichopus californicus*)**

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The California sea cucumber, *Parastichopus californicus*, is commercially and subsistence fished in Alaska, however few studies determined life-history characteristics such effects maternal diets on overall female fitness. Lipids and proteins act as principal energy sources and structural components utilized in development, growth, and reproduction, with variations directly linked to reproductive success and growth/survival rates. This study aims to determine the effects of varying lipid and protein levels on female *P. californicus* egg production, egg nutritional provisioning, and early larval growth/survival rates. Broodstock collected from Southeastern Alaska were transported to the shellfish hatchery in Seward, Alaska and divided into high protein and high lipid feed treatments for approximately 12 weeks. Two spawning events were achieved through manipulating water temperatures. Females fed the lipid treatment spawned during both trials, while females fed the protein treatment only spawned during the first trial. Female weight and mean egg diameter did not vary significantly with feed treatment. Spawning eggs per female varied from 329,000 (lipid treatment) to 792,000 (protein treatment). Fertilization percent for the lipid treatment was 93%, while the protein treatment was 98%. Percent larvae survival for 5 days post spawn ranged between 9% (protein) and 31% (lipid). Interest has been expressed in creating an aquaculture that could potentially be used in stock enhancement for exploited fishing areas. The preliminary data from this study can be used to further our understanding of factors affecting female fitness and could potentially be applied to improve management of this valuable Alaskan fishery.

**Climate-Related Variability in Abundance of Mesozooplankton  
in the Northern Gulf of Alaska 1998-2009**

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Data are presented on the inter-annual changes of zooplankton abundance in relation to water mass properties in the northern Gulf of Alaska. At-sea surveys were undertaken during the month of May from 1998 to 2009 to collect data on zooplankton abundance and water mass properties. Significant changes in temperature, salinity and zooplankton abundance were identified during this period. *Thysanoessa inermis* and *Calanus marshallae* had increased abundances in years when there was a strong phytoplankton spring bloom preceded by anomalously cold winters. *Pseudocalanus* spp., *Neocalanus plumchrus*/*N. flemingeri*, *Euphausia pacifica* and *Oithona* spp. were more resilient to relatively high mean water temperatures. High zooplankton abundances in years of substantial cross-shelf mixing suggest that iron and nutrient transport between the shelf and oceanic domains are essential for sustaining high zooplankton populations via phytoplankton blooms. The abundance of zooplankton in the northern GOA is highly influenced by advective processes and changes in temperature. Further understanding of biological and physical mechanisms that control the GOA ecosystem are of major importance to predict the response of zooplankton communities to environmental changes.

**The Role of Large Scale Stream and Watershed Restoration in the Maintenance, Preservation and Restoration of Salmonid Productivity in Alaska**

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Restoration of Alaska's degraded freshwater habitats is critical to the long term maintenance, preservation and restoration of salmonid productivity. Recent monitoring of large scale restoration projects on Prince of Whales Island and on the Kenai Peninsula in Alaska has shown significant improvements in both physical habitat and salmonid abundance. The coastal watersheds of the Tongass National Forest contain over 50,000 miles of rivers and streams and are the most productive freshwater Pacific Salmon habitat in North America. However, early logging practices in the 1960's-70's resulted in long-lasting, detrimental effects on aquatic habitat conditions in some watersheds. The Harris River Restoration Project is watershed scale restoration effort which reduced erosion sources, eliminated fish migration barriers, improved aquatic habitat complexity and diversity, and restored flood plain riparian function and condition. The Kenai Peninsula supports the largest recreational sport fishery in the world and contributes to extensive commercial and subsistence fisheries. Resurrection Creek, a 415 sq. kilometer watershed located on the Kenai Peninsula near Hope, Alaska, was home to Alaska's first gold rush in 1896. The lower reaches of Resurrection Creek and tributaries were mined extensively for placer gold in the late 1800's through early 1900's adversely impacting high-quality, salmon, trout and char habitat. In 2005 and 2006, the Chugach National Forest launched a large scale rehabilitation project to restore the stream channels, floodplains and fish habitat within Resurrection Creek. Fish response to the restoration was immediate and dramatic increasing adult spawner abundance of some species within the project area by 3,000%.

**Inter- and Intra-Annual Variation in Marine Growth of Juvenile Salmon Off SE Alaska**

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Growth is a key physiological process, clearly linked to the fitness of individual fish and in composite, a marker for the productivity of salmon populations. A novel method to index growth rate has been developed that uses measures of the hormone insulin-like growth factor (IGF1) circulating in a fish's blood. Laboratory experiments have demonstrated that IGF1 correlates well with growth rates over periods of 1 to 2 weeks ( $r = 0.6$  to  $0.9$ ) in juvenile salmonids. A positive relation (2000 - 2010) has been found between plasma IGF<sup>-1</sup> levels of juvenile coho salmon in the Northern California Current and both 1) an index of relative food abundance and 2) subsequent survival of adult coho the following year. This suggests that inter-annual variation in ocean conditions results in altered growth rate of juvenile coho salmon and that these growth differences affect subsequent adult survival.

Plasma samples have been obtained from juvenile cono, cnum and sockeye salmon collected in ocean surveys from Icy Strait, the Gulf of Alaska and from waters of Northern British Columbia (2009-2010). These samples show clear spatial differentiation, with higher growth rates found in the Gulf of Alaska as compared to Icy Strait. Similarly, growth rates of juvenile salmon from Dixon Entrance and Hecate Strait were higher than those found in Queen Charlotte Sound. The potential for regional and inter-annual variation in marine salmon survival will be discussed.

### **Humpback Whale Foraging Structures Winter Schooling Behavior of Pacific Herring and Facilitates Commensal Predation by Multiple Predators**

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As humpback whale populations recover from the large-scale harvests of the twentieth century, they play an uncertain role in structuring of marine ecosystems. Understanding the impact of whales on their forage base will be an important component of ecosystem management. We examined the association between humpback whales and the winter schooling behavior of Pacific herring in Lynn Canal, Alaska. We measured herring abundance, distribution and school structure through monthly hydroacoustic surveys between November and February during the winters of 2007-2008 and 2008-2009. We simultaneously estimated the number of whales present in the area for each month. The spatial and temporal distribution of humpback whales was strongly associated with herring schools during the early stages of the winter in both years. Humpback whale foraging correlated with dispersed schooling behavior of herring. When whales were most numerous, herring were spread over a larger area and broadly distributed throughout the water column. As winter progressed, humpback whales departed the area, and the spatial and vertical extent of herring decreased as they consolidated into dense schools in deep channel habitats. The late winter behavior is presumed to be a metabolically beneficial strategy during winter months when prey is scarce and fish are maturing. We have observed seabirds and pinnipeds associating with whales and capitalizing on whale foraging efforts during the winter months. The disruption of herring schools by foraging whales apparently makes herring available to other predators with limited diving abilities. These associations are persistent (months) and predictable (spatially and temporally), likely facilitating a long-term foraging strategy for multiple species during winter months when herring are enriched in lipid content. We hypothesize humpback whale foraging facilitates commensal predation which may have profound effects on winter survival of other herring predators. As humpback whale numbers increase, this may represent a mechanism of top-down control on herring populations contributing to the direct effects of whale predation.

### **Acoustic Assessment of Juvenile Herring in Prince William Sound**

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Hydroacoustic surveys have been successfully conducted on adult Pacific herring 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. A major hypothesis is that the critical mortality occurs over the first winter of the herring life history, so the hydroacoustic assessment was focused on age 0 herring and combined with energetics, disease and predation research. A key to successful hydroacoustic surveys is species identification, or in this case, identification of age 0 herring. Adult herring (3+) during winter are characterized by large, high-density schools that are virtually monospecific, thus readily detected and identified. Age 0 herring are more dispersed, although usually distributed near the heads of protected bays during winter. We are in our 5th year of both fall and late winter surveys. In some circumstances we have been able to identify and quantify age 0 abundances. In other cases, species and sizes appear mixed and are difficult to quantify. The major challenges to improved quantification are the species identification, the widespread dispersal and uncertainties in the degree of over-winter movements among locations.

**Check it out!! It's Really Simple and Cool: Calculating Basal Metabolic Rates (BMR) in Pacific Herring (*Clupea pallasii*) Using Simple First Derivatives and Integration Calculus Functions**

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In a study to evaluate the recovery of Prince William Sound Pacific herring (*Clupea pallasii*), basal metabolic rates (BMR) were calculated for starving age-1 and age-2 herring using oxycalorific energy equivalents of energy consumption (calculated by differences in energy content over time) over the course of the experiment. Energy content was reported from weekly subsamples in joules (J) from bomb calorimetry and proximate analysis (fat and protein values were converted to J using conversions of 38.9 kJ · g fat<sup>-1</sup> and 17.3 kJ · g protein<sup>-1</sup>). Energy content values were then converted into oxycalorific equivalents, (using the oxycalorific equivalent of 13,556 J · g O<sub>2</sub><sup>-1</sup>) and reported as g O<sub>2</sub> · g herring<sup>-1</sup> (wet weight). Consumed oxygen equivalents were regressed with time, and fit to a non-linear three parameter asymptotic exponential curve ( $y = a \cdot e^{-cx}$ ). First derivative functions were used to convert the oxycalorific equivalents (g O<sub>2</sub> · g fish<sup>-1</sup>) into rate functions of g O<sub>2</sub> consumed · g herring<sup>-1</sup> · day<sup>-1</sup>. As the rate changes over time, first derivative rate functions can be integrated for any time series of the curved area to give a summed amount or set of amounts which can then be used alone or for comparisons.

**Failures of Bioenergetic Models to Accurately Predict Mass Loss in Fasting Pacific Herring (*Clupea pallasii*)**

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Most people have learned that cold blooded animals have their metabolic rates set by temperature, but this may not be entirely the case. A laboratory study of fasted herring indicated young-of-the-year herring reduced their metabolic rates by up to 67% during low food periods. Reduced metabolic rates were determined in the laboratory by periodically measuring energy contents of fasted herring and converting energy loss rates into consumed oxygen rates. We evaluated the significance of the down-regulated metabolic rates by comparing the observed mass loss to predictions from a commonly used bioenergetic model (Wisconsin model). Model predictions were generated using 1) published unadjusted respiration model parameters (for non-starving herring) and 2) our observed respiration rates. Using the published parameters the Wisconsin model underestimated the observed weights of fasted fish by 60%. After adjusting model parameters to reflect the down-regulated metabolic rates, the Wisconsin model predicted weights that differed from our observations by < 10%. So, what does this mean? Well specifically, down regulation may improve survival rates of herring during low food periods and the use of bioenergetic models to predict energy loss of overwintering fish must account for down regulation of metabolic rates.

### **Are Creosote Pilings a Hazard to Herring Embryos?**

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Creosote treated wood is a building material for docks, harbors, and other marine structures in Alaskan waters. Creosote is manufactured from distilled coal tar, contains up to 85% polyaromatic hydrocarbons (PAH), and functions both as a wood preservative and a pesticide. Chronic leakage of PAHs may be harmful to essential fish habitat, particularly for early life stages. Pacific herring (*Clupea pallasii*) spawn nearshore on vegetation such as sea grasses, algae, and other substrates, including on or near piling structures. This poster reports on the lab component of our study to determine the toxicity of leachate from creosoted wood to herring embryos. These levels will be compared to environmental levels of PAH from existing pilings in the Juneau area. Pacific herring embryos from 21 different females were exposed to seven doses of creosote treated wood effluent under controlled laboratory conditions. Dose levels of PAH, monitored by GCMS, ranged from 0.14 to 26 ppb PAH. After 15 days of exposure, slides with eggs attached were removed from exposures and allowed to hatch over the next few days. Skeletal deformities and reduced swimming ability were the most sensitive indicators of effects. The 50% effective concentration (EC50) for creosote derived PAH is approximately 16 ppb. Skeletal deformities and reduction in swimming ability as a result of PAH exposure in teleost fishes are known to have negative effects on long term survival. The question remains if these dose levels are ever achieved in the environment near pilings. This field study is currently in progress.

### **An Interdisciplinary Sustainability Assessment of the Skate Fishery in Prince William Sound, Alaska: Movement Patterns, Stock Assessment and Bioeconomic Modeling**

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Skates are in growing demand worldwide. In 2008, the U.S. landings of skates, mainly from the Atlantic Ocean, totaled 65 million pounds, worth US\$11 million. Because skates are long-lived, mature late in life and possess slow intrinsic growth rates, they are vulnerable to overfishing. As such, many Atlantic Ocean skate stocks are depleted. In contrast, Alaska has relatively healthy skate stocks and there is increasing economic pressure to develop fisheries for them. Big (*Raja binoculata*) and longnose (*R. rhina*) skates are the most commonly landed skates in Alaska and a directed fishery is being developed in Prince William Sound (PWS). To sustainably manage this marine resource more biological information is needed. Our goals are to 1) use satellite telemetry and conventional tags to understand habitat use, movement and transfer of skate biomass among management areas, 2) use this information to develop a mark-recapture-based stock assessment for PWS skates and 3) build a bioeconomic model of the proposed skate fishery. To accomplish these goals, skates were tagged with pop-up satellite and conventional tags during the Alaska Department of Fish and Game's 2011 PWS summer trawl survey. In this poster, we present preliminary results from our tagging experiments and a framework for developing a spatially explicit stock assessment and bioeconomic model for PWS skates. This information is important for managing existing and proposed future skate fisheries.

**Regional and Seasonal Food Habits of Adult Salmon in the Gulf of Alaska and Implications for Mortality of Age-0 Marine Fish**

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The Upper Trophic Level (UTL) Gulf of Alaska Project conducted fisheries oceanographic cruises during summer and fall months in the southeastern and central Gulf of Alaska (GOA). Immature and maturing salmon comprised the majority of piscivorous predators encountered in the surface 20-meters of the GOA. Surveys conducted in the summer and fall collected stomachs from all five species of Pacific salmon from each region. Stomach contents were analyzed to quantify predation pressure on five target species of age-0 marine fish, provide data for ecosystem modeling efforts, and to determine spatial and temporal differences adult salmon have on ecosystem structuring in the GOA.

**Deep and Shallow Genetic Structure Among Red King Crab Populations in Alaska**

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Mitochondrial (mt) DNA sequence variability was used to assess the sources of variability in Alaskan populations of red king crab. Populations are genetically homogeneous in the central part of the range from southeastern Bering Sea to Kachemak Bay, but are heterogeneous in marginal areas in the western and northern Bering Sea and in SE Alaska. Heterogeneity among SE Alaska populations likely reflects isolation in semi-enclosed fjords, but heterogeneity among Bering Sea populations represents historical isolations in ice age refugia. Populations show a strong gradient in genetic diversity, which is large in western populations, moderate in central populations, but drastically reduced in SE Alaskan populations. This gradient appears to be due to repeated extinctions during glacial maxima in the eastern North Pacific and to colonizations by crabs from Asia. However, present-day populations appear to have been colonized since the last glacial maximum by crabs from local glacial refugia around Kodiak Island and around the Queen Charlotte Island, which were partially unglaciated. Bayesian skyline plots of the three major evolutionary groups show rapid population growth since the last glacial maximum, when coastal deglaciation opened large areas for colonization. These results support the management of red king crab populations on a small geographic scale.

### **Epizootiological Observations from Five Years of Ichthyophonus Monitoring in Pacific Herring Populations**

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High prevalences of *Ichthyophonus*, an internal Mesomycetozoean parasite of marine fishes, occur in populations of Pacific herring *Clupea pallasii* throughout the NE Pacific. Infection prevalence varies with geographic location, season, and population age structure, with the prevalences in adult herring from Prince William Sound ranging from 12 - 45% during 2007-2011. Although the geographic and host ranges of *Ichthyophonus* are extremely broad (see poster by Gregg et al), the latitudinal range of the parasite in Pacific herring appears to end north of California (southern extreme) and south of the Bering Sea, Alaska (northern extreme). There is no indication that Pacific herring are able to clear the infection; therefore, a seasonal decline in *Ichthyophonus* prevalence that occurs from spring through autumn each year likely reflects selective mortality among *Ichthyophonus*-infected cohorts.

### **Seasonal Fish Use of Nearshore Habitats in Southwestern Cook Inlet**

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Sampling of nearshore and demersal fish in two bays on the west side of lower Cook Inlet has been conducted in various months from March through November, since 2004. The study's purpose has been to assess local fish and invertebrate assemblages prior to potential nearshore development. Stations were spread widely through out the bays to examine both fish occurrence and degree of utilization of several habitats. Methods employed included beach seine, bottom trawl, gill net, trammel net, angling and visual Pacific herring spawn surveys. In addition to characterizing local assemblages, we conducted stomach content analyses (SCA) as a measure of utilization of prey resources by a subset of ecologically and/or economically important fish species. Results show a consistent pattern of habitat use by several species of commercially important fish as well as by forage fish important in area food webs. Juvenile herring was the most abundant species overall; these fish were present from March through November with numbers peaking in mid June (for Age 1 fish) and August/September (for Age 0 fish). Herring numbers decreased along shorelines and increased in bottom trawls in the fall, suggesting an offshore movement as water temperatures decline. Juvenile chum and pink salmon began occurring in beach seine catches in April while considerable ice remained in the study area. Chum salmon numbers peaked in May and declined sharply by June. Pink juveniles were present in moderate numbers from May though July, declined sharply in August and were no longer captured after September.

**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 empirical mortality and energy density levels following forced fasting was applied to age-0 Pacific herring (*Clupea pallasii*) of Prince William Sound, Alaska. The frequency distribution of energy density measured during November 2007-2010 was used as model initial conditions. The model was validated by comparing observed energy distributions in March 2008-2011 to model predictions. Modeled mortality from November to March, April, and May resulted in survival rates of, respectively, 22, 5, and 1.2%. Mortality from starvation from November through May thus explains the two orders of magnitude range observed for herring recruitment in Prince William Sound if there is no starvation mortality for cohorts leading to peak recruitment levels (~ 1 billion age-3 herring). Observations of November and March energy density for cohorts recruiting at 1 billion 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, actually parasitic copepods, on age-0 herring during their first months following metamorphosis suggest this as a possible energy sink.

**Food Sources Utilized by Herring in Relation to Other Juvenile Fishes Rearing in Nursery Habitats During the High Latitude Winter**

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Recruitment of Pacific herring in Prince William Sound, Alaska (60 degrees N) is presently very low. A posited recruitment driver is competition with sympatric fishes in nursery bays. Juvenile herring were found in 9 of 15 sites surveyed in March 2010. Of these sites, herring and other fishes were sympatric in 8. Juvenile gadids and herring were sympatric at 7 sites and allopatric in 5. Capelin and herring were sympatric at 5 sites and allopatric in none. Stable isotope analysis of these fishes suggested that there was relatively little competition for food sources by sympatric gadids. Each species had consistent isotope values regardless of whether they were sympatric or allopatric. Competition with gadids would thus be for space rather than for food. There was partial overlap in the isotope value range of capelin with herring. The isotopic values of yearling and older juvenile herring fell within the range of sub-yearlings suggesting that intra-specific competition may be more important than inter-specific competition. It would be interesting to speculate how these interactions would differ with 2-3 orders of magnitude more herring.

### **How Biophysical Dynamics Predict Differences in Juvenile Chum Salmon (*Oncorhynchus keta*) Physiology**

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Chum salmon are an important commercial fishery in Southeast Alaska; therefore, gaining a better understanding about mechanisms affecting their recruitment is needed. By identifying biophysical indicators that affect physiological status of seaward migrating juvenile chum salmon, this project may provide valuable ecosystem metrics to help refine forecasts for hatchery and wild chum salmon as well as other salmon species in Southeast.

Over the past two years, two NOAA projects, the Gulf of Alaska Integrated Research Project (GOAIERP) and the Southeast Alaska Coastal Monitoring Project (SECM), have sampled stations offshore and inshore of Southeast Alaska to collect juvenile chum salmon and biophysical data. 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. Collecting samples along transitional habitats will allow us to determine if biophysical parameters predict differences in the physiological status of juvenile chum salmon. Additionally, we will be able to examine stock-of-origin differences in juvenile chum salmon physiology between offshore and inshore marine environments. This graduate study is partially supported by the University of Alaska Fairbanks, the Alaska Sustainable Salmon Fund, and several Regional Aquaculture Associations in Southeast Alaska.

### **Climate Induced Changes in the Phenology and Evolutionary Potential of Multiple Salmonid Species**

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Salmon are a massive source of nutrients in coastal food webs, income to human communities and integral part of traditional cultures in the North Pacific. An important phenotypic trait in salmonids that may be affected by climate change is migration timing, because in many populations this trait is locally adapted to freshwater and marine conditions and is highly heritable. We used long-term census data to investigate patterns of migration timing for five species and various life histories of salmonids in a freshwater stream in Southeast Alaska. The most dramatic pattern is that across most species and life histories migration into and out of freshwater is occurring earlier, and intra-annual phenotypic variation in migration timing is decreasing. We used an information theoretic approach to model selection to identify the environmental conditions responsible for inter-annual variation in migration timing for these populations. In the majority of populations marine or freshwater temperatures appear to play a role in influencing migration timing, strongly suggesting that climate change impact salmonid population and evolutionary dynamics in the future.

### **Preliminary Evaluation of Fine-Scale Population Genetic Structure of Northeastern Gulf of Alaska Pacific Ocean Perch**

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Marine species with pelagic larvae and mobile adults are often assumed to have populations that are continuous throughout their natural range. However, recent studies in our laboratory of Pacific ocean perch (POP: *Sebastes alutus*) have demonstrated significant genetic divergence among collections sampled at about 400 km intervals along the GOA and BSAI continental slopes. Rockfishes generally and POP specifically are important commercially and ecologically, and knowledge of spatial population structure is critical for conservation and management. To better determine the appropriate scale for effective and prudent management, we are analyzing samples collected by a more closely spaced sampling pattern than in previous studies. Our samples were collected along the continental shelf margin from Yakutat to Kodiak, many in clusters that were as little as 25 km apart, so as to obtain information about the fine scale population structure. We are analyzing the samples with the same microsatellite loci that were used in previous studies. In our preliminary analyses of fish captured near to and just north of Kodiak, we have confirmed the isolation-by-distance relationship that we observed in our earlier studies. Geographic structure will be interpreted using landscape genetics techniques informed by environmental parameters.

### **Application of Machine Learning Models to Predict Fish Species Distributions in Alaskan Estuaries**

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Models that predict species distribution and community composition by combining observed occurrence data with spatial environmental data can provide important information for management and research. These models provide detailed baseline information that can be incorporated into species assessment and management strategies. Alaska has approximately 31,383 miles of tidal shoreline. Throughout much of this area, complex topography coupled with ample rainfall from Gulf of Alaska weather systems creates numerous estuaries that are important habitat for a variety of fish of commercial, recreational, and subsistence importance. To date, there have been few analyses linking estuarine-associated fish species to physical habitat variables in Alaska, and no comprehensive analysis to predict distribution of these species from physical habitat features. Increased availability of digitized spatial environmental data and advances in computer learning algorithms has enhanced the ability to develop accurate predictive models of species environmental requirements and geographic distributions. These data mining approaches have been used with substantial success to develop habitat suitability models for land and freshwater aquatic species. We apply ensemble modeling approaches to seine and trawl data collected by the National Marine Fisheries Service in Alaskan estuaries from 1998 to 2006 and demonstrate that these approaches can accurately predict distributions for many estuarine-associated fish species.

**The Gulf of Alaska Project Upper Trophic Level: Preliminary Findings from the First Field Season**

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The Gulf of Alaska Project is a recently initiated North Pacific Research Board integrated ecosystem research program focused on identifying and quantifying key processes that regulate the recruitment of five commercially and ecologically important groundfish species in the Gulf of Alaska (GOA). The focal species of the project are Pacific ocean perch, sablefish, Pacific cod, walleye pollock, and arrowtooth flounder; all species which demonstrate different life histories, but experience the same oceanographic conditions during their first year of life. Fisheries oceanographic cruises were conducted during summer and fall months in the both southeastern and central regions of the GOA. Regional differences in oceanographic processes occurring during spring, summer, and fall are being investigated by the Lower Trophic level (LTL) component of the study, which will eventually relate environmental conditions to species specific health, condition, and recruitment. The Middle Trophic Level component is investigating interactions with forage fish species and subsurface fish assemblages with hydroacoustics. Preliminary findings from surface and pelagic trawl sampling for the first of two years of comprehensive field studies are reported.

**Estimated Metabolic Costs Associated with Locomotion in Pacific Herring (*Clupea pallasii*)**

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Bioenergetic models need to account for metabolic costs associated with locomotion, but these data are often missing. Modelers often scale routine metabolic rates upward about fourfold to account for the costs associated with activity. We examined the cost of locomotion in adult Pacific herring (*Clupea pallasii*) by swimming them at different speeds and recording oxygen consumption rates in a respirometer. We acclimated schools of 5 to 6 herring to the respirometer for 4 hours prior to monitoring oxygen consumption rates at approximately 6° C. Speeds were stepped up in half body length intervals from 1 to 4 body lengths. We examined the oxygen consumption rates in two size classes of herring. In all cases, oxygen consumption rates were a parabolic function of swimming speed such that the minimum consumption rate occurred near 2 body lengths per second. At the minimum speed oxygen consumption was approximately threefold that of routine metabolic costs, as measured in fasted fish in a separate study. These data indicate that bioenergetic models employing a factor of four are not overestimating the costs associated with active foraging or migration.

### **Geolocation of Demersal Fishes in Alaska Using Geomagnetic Archival Tags**

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The ability to track marine fishes during large-scale movements such as seasonal or ontogenetic migrations is needed for spatially explicit fisheries management. However, current tracking methods, including acoustic telemetry and light-based geolocation, are very limited for Alaska's deep water, demersal fish species. We are developing a new method for obtaining information on the meso- to large-scale movements of demersal fishes using archival tags that record information on the earth's magnetic field. Because the earth's magnetic field varies over space, geolocation can be performed by matching magnetic field values recorded by archival tags on fish to modeled values within the study area. The precision of this new method is expected to vary based on the measurement resolution of the archival tag, the orientation of the magnetic fields in the study area, and the movement trajectory of the tagged animal relative to the orientation of magnetic fields. We will 1) provide a theoretical estimate of the precision of this method in Alaska based on the measurement resolution of currently available archival tags and simulated fish movements in different regions, and 2) provide an update on the application of this method for geolocation of Pacific halibut, Pacific cod, and sablefish.

### **Preliminary Evaluation of Combining Genetics and Population Dynamics to Improve the Management of Pacific ocean perch, *Sebastes alutus*.**

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Pacific ocean perch (POP) are the most abundant *Sebastes* rockfish species in Alaskan waters in both biomass and catch. Genetic studies of POP population structure have demonstrated that relatively strong divergence occurs between collections at locations spaced about 400 km apart along the Gulf of Alaska (GOA) and Bering Sea (BS) continental slopes (Palof et al. 2011). The degree of divergence suggests that, although population structure is not a consequence of geographic or oceanographic boundaries, the limited net dispersal that occurs in both pelagic larvae and adults restricts the spatial scale of POP production to areas that are related to the average distance moved between birth and reproduction called neighborhoods. The spatial scale of neighborhoods is the geographic scale on which management should focus. Incorporating demographic information from our genetic studies requires an evaluation of the current POP survey and fishery data. In this study, we plan to develop a robust estimate of neighborhood size, determine if there is natural spatial variability that can be detected in current population modeling, and use simulations to evaluate the interaction of spatial structure with population dynamics and harvest models for POP. Estimates of lifetime dispersal for POP were estimated from genetic data to fall within the range of 70 to 140 km. We present an evaluation of spatial management using the current population models at smaller scales, both regional and NMFS regulatory areas. Initial results suggest differences in estimates of recruitment and other parameters by region, but further robust testing is underway.

**Eddy Identification and Transport in the Gulf of Alaska:  
Links to Simulated Particle Retention and Transport Patterns**

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Several commercially important groundfish species (such as walleye pollock, Pacific cod, Pacific ocean perch, and sablefish) spend their early life in the Gulf of Alaska (GOA). When spawning and nursery areas are spatially distinct, transport processes are critical to ensure connectivity between these areas while retention processes are relevant to ensure survival when spawning and nursery areas are the same. In the GOA, there is a high level of mesoscale activity characterized by the presence of eddies and meanders that promotes both transport and retention within different GOA regions. The objective of this preliminary study was to identify eddies (through the Okubo parameter) and their persistence in time from output of a physical oceanographic model (ROMS), and to link them, by means of convolution indices, into trajectories. We then link the eddy trajectories to the transport of early life stages of walleye pollock simulated using an individual-based modeling (IBM) approach. The spawning-nursery area relationship for walleye pollock is explored as a study case, where eddies/meanders and their progression in time are assessed as potential oceanographic features linking spatially complex spawning-nursery areas for walleye pollock through advective processes.

**Factors Influencing Spatial Patterns of Overwintering Survival of Age-0 Pacific Herring**

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It has been hypothesized that mortality during the first winter of be an important factor in controlling the recovery of Pacific Herring in Prince William Sound. Generally this hypothesis has been used to look at the condition of the fish entering the winter with the belief that fish in better condition can survive through a winter fasting period. The energetics argument can be used to help explain some of the temporal variability in survival between years, but may not be enough to explain the springtime distribution of fish. During the fall the distribution of age-0 herring appears to be fairly ubiquitous. Yet in the spring the distribution of surviving age-0 herring seems much more restricted. Described here is the difference in the distributions and preliminary discussions about factors that may be important in determining the spring distribution. Such factors include habitat qualities such as exposure and the presence of sheet ice, as well as factors of predation and the presence of adult herring.

### **Locating Acoustic-Tagged Fishes and Describing Their Environment Using an Autonomous Underwater Vehicle**

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

### **Spatial and Interannual Variability in Growth and Body Composition Over Winter in Juvenile Pacific Herring (*Clupea pallasii*) from Prince William Sound**

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Variable survival rates during the first winter of young-of-the-year (YOY) fish can strongly influence year-class strength. Survival of YOY fish often depends on having energy stores sufficient to ensure survival until food abundance increases in spring. We are assessing the potential use of growth rates and body composition as indicators of overwinter performance for YOY herring in Prince William Sound (PWS). Our working hypothesis is that fall growth predicts winter survival. In the first two years of our three-year study, we found that overwinter changes in size, growth, and body composition of YOY herring differed among bays in PWS, and between years. Consistent with our hypothesis, fall 2009 YOY herring from Eaglek and Simpson bays had lower RNA/DNA than YOY in Lower Herring Bay. YOY from Eaglek and Simpson bays lost weight and appeared to experience greater reductions in abundance than Lower Herring Bay over winter. In fall 2010, YOY from Lower Herring and Simpson Bay had high RNA/DNA, and gained weight over winter. 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.

### **The Gulf of Alaska Project Upper Trophic Level Benthic Habitat Research**

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One of the main objectives of the Gulf of Alaska (GOA) Project is to identify and quantify the major ecosystem processes that regulate recruitment strength of five key groundfish species in the GOA. We hypothesize that early life survival of these marine fish is regulated in space and time by climate-driven variability in a biophysical gauntlet comprising offshore and nearshore habitat quality, larval and juvenile transport, and settlement into suitable demersal habitat. Here, we seek to characterize and quantify nearshore demersal habitat to determine the success of young-of-the-year (YOY) fish settlement in the final stage of the gauntlet. Our primary objectives are to develop individual preferred habitat models for the five focal groundfish species and apply this information to newly created geomorphic maps of the nearshore. Literature synthesis and field observations will be used to create the species specific habitat models. Best available bathymetry maps are currently being combined with gridded seafloor-characteristics data from the usSEABED database to create the first regional contextual three-dimensional observations of rock and sediment distributions in the GOA. Together, this information will provide a knowledgeable, scalable, basis for YOY habitat suitability analysis. Regional maps of the predicted suitable benthic habitat will be created for each of the five focal species using the preferred habitat model and the three-dimensional sediment layers. These maps will then be provided to the other GOA Project components for developing the nearshore survival model.

### **Variability in Red King Crab Population Estimates in Southeast Alaska**

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One of the main goals of fisheries science is to provide the best stock assessment information to managers. This is a 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 of red king crab that exist in discrete areas. Here we examine the utility of biomass estimation methods used by the Alaska Department of Fish and Game (ADF&G), improve the understanding of red crab distributions, and foster collaborative efforts between the ADF&G and the red king crab commercial fleet by comparing three independent biomass estimates. Specifically, we compare a Catch Survey Analysis (CSA) model with depletion and mark-recapture estimates for six areas. CSA estimates use ADF&G summer survey data, while depletion and mark-recapture estimates were done during the fall on commercial vessels. Approximately 9000 crab were caught and tagged. Of the crab recaptured 1-2 months later, 3 - 29% of them were tagged. The depletion model only produced an estimate for St. James Bay and estimated 30% fewer crab than the CSA model. The mark-recapture estimates averaged 3.6 ( $\pm 1.6$  SE) times more crab than the CSA model. In addition, mark-recapture data suggests large changes in crab behavior (movement and catchability) over relatively short time scales (months).

**Spatial and Temporal Distributions of Pacific Halibut from Eggs to Larvae in the Eastern Bering Sea and the Gulf of Alaska**

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Pacific halibut is an ecologically and commercially important species in the eastern Bering Sea and Gulf of Alaska. Their total population density is large in both systems, however since 2000 their estimated biomass has exhibited different trajectories with an increase in the Bering Sea and a decrease in the Gulf of Alaska. Recently, most Pacific halibut studies have focused on adult population dynamics, for the purpose of stock assessment and management, whereas there have been fewer studies on early life stages. We expect that changes in adult population dynamics are influenced by changes in dynamics of early life stages and vice versa. Therefore, using over 25 years of ichthyoplankton data, we examined the relative contribution of environmental variability and adult population size on the phenology and geography of Pacific halibut eggs and larvae in both systems. A generalized additive model is utilized to identify the effects of abiotic (i.e., water temperature) and biotic (i.e., adult population size) variables on abundances and distributions of Pacific halibut in time and space. The results from this study are valuable for understanding the population dynamics of Pacific halibut in light of observed changes in the temporal and spatial distributions of their early life stages.

**An Investigation of Northeast Pacific Groundfish Recruitment Variability Driven by the Environment**

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Marine ecosystems respond in a variety of ways to physical and biological forces through direct and/or indirect pathways, causing the abundance and productivity of marine species to vary over a broad spectrum of time scales. Species with related life history characteristics may show co-variations in the timing and frequency of responses to changes in the environment. We used time- and frequency-domain analysis of recruitment and stock-recruitment residual time series to evaluate the dominant time scales of variability in the population dynamics of commercially harvested groundfish stocks from the Gulf of Alaska, Bering Sea, and California Current. Using multivariate statistical techniques, including cluster analysis, we then identified groups of stocks based on similarities in the timing and frequency of these recruitment indices. This was then linked to environmental variables potentially important to recruitment of these stocks using conceptual and statistical models. While preliminary results of this analysis show some grouping based on biologically related species groups (e.g., rockfish, flatfish, gadids), correlation between these groupings suggest similarities in exposure to environmental factors in early life history. Further analysis will investigate the possible role that physical and biological factors play in recruitment variations, and how these results can contribute to stock assessments.

### **Implications of Temperature-Dependent Egg Stage Development Rates for Arrowtooth Flounder in the Gulf of Alaska**

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Understanding recruitment is central to rational fishery and ecosystem planning. Recruitment is thought 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. Temperature, in particular, is known to have a substantial effect on development and growth rates. We developed a coupled biophysical Individual-Based Model for arrowtooth flounder (*Atheresthes stomias*) to test the hypothesis that recruitment for this species is principally 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 used the Regional Ocean Modeling System (ROMS) to provide a high resolution simulated environment (3D currents and temperature) within which we released thousands of simulated arrowtooth eggs from potential spawning sites on the continental slope across the GOA and at different times. Individuals were tracked as horizontally-passive particles from spawning locations through the end of the egg stage. Vertical location varied with egg stage, consistent with field data. We investigated the potential impact of spatial and temporal variations in temperature on egg stage duration using temperature-dependent development rates developed from laboratory studies. Because individuals experience different temperature histories along different transport pathways, individuals spawned at the same time but in different locations may undergo substantially different egg stage durations prior to hatching, potentially resulting in substantially different survival rates.

### **Nearshore Piscivory During the Winter in Prince William Sound**

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Pacific herring (*Clupea pallasii*) populations in Prince William Sound have been suppressed for nearly two decades, attributable to a suite of potential drivers. We examined the potential for top-down control of juvenile herring by fish predators in Prince William Sound during the winters of 2009â2011. As part of a multi-vessel effort, we conducted 2 consecutive sets of November and March cruises. We sampled via a combination of longlines and gillnets to capture piscivorous fishes in near-shore regions where juvenile herring were observed during hydro-acoustic transects. Forty-six species of potential herring predators were caught during our surveys; gadids accounted for 53.3% (n=853) of all fishes (n=1598) caught. Pacific cod (*Gadus macrocephalus*) in particular accounted for 27.7% (n=442) of the total fishes caught. Preliminary diet analyses (n=95 stomachs) have revealed Pacific herring in 17.9% of the Pacific cod stomachs examined to date (n=56), accounting for as much as 16% (by mass) of fish matter found in cod stomachs. Pacific cod are among the most abundant predators that overlap spatially with juvenile herring in Prince William Sound and may account for significant amounts of herring predation.

**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 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 *Chionoecetes bairdi* habitat northeast of Kodiak Island in the GOA. For the first time, we will use 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. We hypothesize that 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.

### **Linking Hydroacoustic Surveys for Juvenile Herring with Winter Seabird Distribution in Prince William Sound**

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Seabirds in Prince William Sound (PWS) may face their greatest pressures and competition for food during winter. The distributions of seabirds are likely influenced by the distribution of their food resources such as Pacific herring (*Clupea pallasii*), an energy-rich forage fish. We conducted seabird transects concurrent with hydroacoustic juvenile herring surveys in PWS during November and March over a four-year period (2007-2011). We compared Pacific herring abundance, spatially and temporally, relative to the distribution and abundance of the most abundant seabirds in PWS. Both total fish and total adult herring biomass did not differ by month while age 0+ herring biomass was significantly higher in November. Among the five bays surveyed, we found differences for total fish biomass but not for juvenile or adult herring. Common Murre (*Uria aalge*), the most abundant winter seabird in PWS, and the avian predator responsible for most of the herring biomass consumption, tended to peak by March. Densities of Common Murre and other abundant species showed no relationship to either total fish biomass or total herring biomass (adult or juvenile). We will examine the seabird-herring associations at a finer (1 km) scale to determine whether within-bay associations show spatial concordance.

### **Kittlitz's Murrelets Nesting in Unglaciaded Alpine Habitat on Kodiak Island, Alaska: Unraveling Parts of the Mystery**

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Kittlitz's murrelet (*Brachyramphus brevirostris*) is a rare seabird that nests in remote mountainous terrain in coastal areas of Alaska and the Russian Far East. It is a species of conservation concern, and currently a priority species for listing under the U.S. Endangered Species Act. Limited available data indicate that nesting success and fledgling recruitment are low. To fill significant gaps in our knowledge of the species' breeding ecology, we studied Kittlitz's murrelets nesting in the open on scree slopes in unglaciaded alpine habitats on Kodiak Island, Alaska. We discovered 53 active Kittlitz's murrelet nests during 2008-2011, and placed remote cameras near 33 nests to elucidate aspects of parental care, chick diet and growth, and factors limiting nest success. Only 28 nests (53%) produced hatchlings and only nine (17%) produced fledglings, confirming low nesting success. The single young fledged only 22 to 27 days post-hatch, suggesting intense selection pressure to fledge early. Chicks that survived to fledging were fed an average of 3.5 to 5.8 meals per day, each consisting of a single fish. Sand lance (*Ammodytes hexapterus*) were the predominant prey type in the diet of chicks at all monitored nests. Red fox depredation and chick mortality on the nest (unknown cause) accounted for approximately 61% and 25% of all failed nests. These results will assist the U.S. Fish and Wildlife Service and other management agencies in Alaska to identify factors limiting reproductive success for this poorly-known candidate species.

### **Avian Influenza Surveillance of Shorebirds and Gulls in Cordova**

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Migratory birds from multiple continents pass through Alaska, providing opportunity for the introduction and generation of novel avian influenza virus. Understanding viral ecology and evolution in Alaska may be critical for understanding the capacity for birds to serve as vectors for novel or zoonotic strains of influenza that may pose a risk to humans. In spring of 2009, we initiated a multi-year surveillance study of shorebirds and gulls near the Copper River Delta to examine the prevalence and diversity of influenza viruses in this critical habitat. Here, we report the results of three years of surveillance collections and resent data on several gull viruses sequenced from these samples that indicate birds in this region spread infection of viral strains with a high degree of intercontinental mixing.

### **Use of Time-Lapse Photography to Monitor Common Murre Productivity on Barwell Island**

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Barwell Island, at the entrance of Resurrection Bay and part of the Alaska Maritime National Wildlife Refuge, is small (15 hectares), steep-sided, and contains nesting habitat for several species of seabirds. When in 2009 the Army Corps of Engineers visited Barwell to seal World War II bunkers that had become seabird traps, the Refuge installed time-lapse cameras to obtain the first measurements of common murre reproductive success on the island.

The Refuge monitors seabird reproductive success at several Alaska sites. This measurement is one gauge of colony condition and can provide insight into causes of population change. Barwell's small size, steep topography and remote location precludes manual methods of regular, through-season direct observation that the Refuge employs for monitoring other nesting colonies.

Advances in digital photography, microcontrollers, and digital storage now permit automatic repeat photography to continue reliably over long time periods in remote locations. We recorded images of nesting murre every three hours for four months, visiting the colony only before and after the nesting season. From these images we determined laying, hatching, and fledging dates and calculated the proportion of eggs that hatched and chicks that fledged. To analyze the images we followed conventional monitoring protocol: in addition to using actual sightings of eggs and chicks, we inferred their presence from the posture of adult murre. Using the images to measure reproductive success was similar to using manual observations. Automated repeat photography can expand monitoring efforts to areas not suitable for repeated manual visits.

**Untangling Longline Depredation: LIMPET Tags on Eastern Gulf of Alaska Sperm Whales Reveal Deep Dives and Local Movements Around the Shelf-Edge that Contrast with Rapid, Long-Distance Migrations Across Stock Boundaries**

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To better understand and mitigate depredation by sperm whales, data on habitat use and whale-vessel associations are needed. In the eastern Gulf of Alaska (EGOA), ~130 male sperm whales have been observed removing sablefish from longlines. We previously attached location-only LIMPET satellite tags to 11 sperm whales near vessels fishing in EGOA during summer in 2007 and 2009. Some whales stayed in EGOA through early fall, moving up to 600 km north or south along the slope edge, while others migrated south shortly after tagging. The furthest travelled 5600 km in < 1.5 mo. Seventy-five percent of locations were over the slope, with little time spent over the ocean basin (22%) or on the shelf (3%). In 2010 we deployed 5 depth-recording satellite-linked LIMPET tags. Whales typically made continuous, repetitive dives to 300-500m, lasting ~30 min. All 5 made dives in excess of 1000 m (1176 to 1848 m). Shallow dives (< 200m), possibly indicative of direct longline depredation, were uncommon. Two whales spent 2 weeks in Chatham Strait, a range extension into Southeast Alaska inside waters, where they interacted with vessels in a different, State-managed fishery. Whales that migrated south transited along the Washington-Oregon-California coast rapidly; nonetheless, there's a possibility that these whales may start depredating new west coast longline fisheries. Beyond demonstrating that sperm whales are capable of extremely deep dives and rapid, long distance movements, our results from LIMPET tag deployments suggest that Alaska males are part of a larger North Pacific population whose boundaries are unclear.

**Calling Behavior 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 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. Each call was quantitatively described and categorized as a whistle, pulsed call, or click train. The vocal repertoire at Eagle Bay for the summer and at Trading Bay for the summer and the winter was analyzed by calculating the total number and relative abundance of each call type and identifying the unique call contours. The repertoires at each location for each season were compared to determine if CIB's vocal repertoire varies temporally or spatially. For summer 2009, there were 214 beluga calls in Trading Bay and over 3000 calls at Eagle River. There was evidence of spatial variation in the relative abundance of call types. There were also unique call contours identified at Eagle River that were not seen in Trading Bay. Next, an anthropogenic noise study will be conducted to attempt to correlate differences in the ambient noise environment with differences in beluga calling behavior.

### **Factors Affecting Haul-Out Probability of Harbor Seals in Tidewater Glacier Inlets**

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Large numbers of harbor seals (*Phoca vitulina*) use tidewater glaciers in Alaska for pupping, breeding, and molting. Glacial fjords are popular tourist destinations, however, vessel traffic can result in disturbance of seals. We explored factors affecting haul-out probability of harbor seals at a site frequented by cruise ships and smaller vessels originating from Juneau, Alaska. In 2008-10, we remotely monitored 97 radio-tagged seals ( $n=63 <1.75\text{years}$ ;  $n=34 >1.75\text{yrs}$ ;  $\sim 1:1$  sex ratio) in Endicott and Tracy Arms (glacial fjords). There was no difference between sex or age classes in number of days located (mean  $34.7 \pm 1.98\text{SE}$ ), or total locations/seal ( $1,347 \pm 81$ ). We monitored vessel presence with time-lapse photography. Factors affecting haul-out probability included amount of ice, tide flow, weather, location, time, and vessel presence. Preliminary results indicate that older females hauled out more and at different times of day than other age/sex classes; haul-out probability was greatest for other seals between  $\sim 08:30-13:30$ . Haul-out probability decreased as vessel numbers increased. A single cruise ship had the strongest negative effect compared to single vessels in other size-classes. As numbers of smaller vessels increased, haul-out probability decreased. Some medium vessels deployed skiffs and kayaks, which also affected haul-out probability and collectively could exert greater influence on haul-out probability than a single cruise ship. These remotely-collected data did not establish seal-vessel distances or direct interactions; more research is needed.

### **Gene Transcript Profiles in Sea Otters (*Enhydra lutris*): a New Paradigm in Ecosystem Health**

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Development of blood leukocyte, gene transcript profiles has the potential to expand condition assessments beyond those currently available to evaluate wildlife health, including sea otters (*Enhydra lutris*), both individually and as populations. The genes targeted in our study included a combination of immune response genes that can be modified by biological, physical, or anthropogenic impacts and consequently provide information on the general type of stressors present in a given environment. Gene transcription analysis for diagnosing or monitoring wildlife health requires the ability to distinguish pathophysiological change from natural variation. Herein we describe methodology for the development of quantitative real time polymerase chain reaction (qPCR) assays to measure differential transcript levels of multiple immune-function genes in the sea otter. We establish a "reference" range of transcripts for each gene in a group of clinically healthy captive and free-ranging sea otters. We compared gene transcript profiles of sea otters sampled in 2008 among areas within Prince William Sound (PWS) impacted to varying degrees by the 1989 Exxon Valdez oil spill with those of captive and wild clinically normal, i.e., reference sea otters. Profiles of sea otters from PWS showed elevated transcription in several genes when compared to the reference sea otter group, indicating possible recent and chronic exposure to organic contaminants. Sea otters from designated oiled areas within PWS 19 years after the oil spill had higher transcription of genes associated with tumor formation, cell death, and heat shock than those from areas not oiled.

### **Humpback Whale Habitat Selection near Tidal Headland-Wakes**

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Headland-wake foraging systems, are commonly exploited by baleen whales and other mobile marine predators though how tidal variation affects the quality of this habitat is poorly understood. We used humpback whale (*Megaptera novaeangliae*) sighting data from 1997 to 2008 in combination with tidal prediction software to investigate the effects of current direction (ebb vs. flood) and tidal amplitude on the distribution and abundance of humpback whales around 3 headlands and 5 non-headlands in Glacier Bay and Icy Strait in southeastern Alaska. Headlands were defined as points of land that disrupt tidal flow creating distinct tideward and leeward conditions. We used an advanced tidal circulation model (ADCIRC) to identify these conditions. Current direction and tidal amplitude each significantly affected whale distribution at only one non-headland ( $\bar{x} \pm 2 = 6.1$ ,  $p < 0.01$ ;  $\bar{x} \pm 2 = 13$ ,  $p = 0.002$ , respectively). At all 3 headlands, current direction significantly affected whale distribution ( $p < 0.0001$ ). Whale abundance was greater in the leeward areas. Tidal amplitude significantly affected distribution at the 3 headlands ( $\bar{x} \pm 2 = 97$ ,  $p < 0.0001$ ;  $\bar{x} \pm 2 = 75$ ,  $p < 0.0001$ ;  $\bar{x} \pm 2 = 6.1$ ,  $p = 0.05$ ) such that whales selected habitat that moderated, rather than maximized, the effect of tidal amplitude, suggesting that headlands also have the potential to be important features in areas with less extreme tidal exchange. Understanding the disproportionate ecological importance of headland-wakes is important for efforts in marine spatial planning to accommodate species diversity and sustainable human use in a finite ocean space.

### **Mercury in Blood and Keratinous Tissue of Piscivorous Mammals**

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A leading hypothesis for the current lack of recovery of western distinct population segment Steller sea lions (SSL; *Eumetopias jubatus*) is poor reproductive success. Steller sea lions are piscivorous and feed at a high trophic level putting them at risk of mercury accumulation. Mercury accumulation can interfere with reproductive function and hinder fetal development. Mercury is transported throughout the body by blood, stored in the liver and kidney and can be excreted via urine, feces and hair. Although hair is the most noninvasive tissue to sample for monitoring mercury concentrations in mammals, we need to understand what hair total mercury (THg) indicates about circulating concentrations. In this study we examined the distribution of THg in blood compartments (plasma and whole blood) and analyzed the relationship between whole blood and keratinous tissue (hair and epidermis) from 22 SSL sampled from the central Gulf of Alaska. Blood and epidermis were analyzed for 15 bottlenose dolphins (BD; *Tursiops truncatus*) to provide a comparative assessment in another piscivorous mammal. Mercury was found in greater concentrations in whole blood than in plasma (SSL  $p < 0.0001$ ; BD  $p = 0.0002$ ). Concentration of mercury in whole blood was linearly related to concentrations of mercury in hair or epidermis in both species. However, SSL had significantly higher ratios of hair to whole blood THg than seen for BD epidermis to whole blood ratios ( $p < 0.0001$ ) suggesting hair is a very effective excretory pathway in sea lions. We conclude that both hair and epidermis are good tissues to monitor mercury concentrations in mammals.

### **Cook Inlet Beluga Whale Behavioral Observations via Video-Monitoring**

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Compiling a comprehensive habitat use assessment of Cook Inlet beluga whales (CIBW), listed in 2008 as endangered, is difficult in general, and nearly impossible for any single monitoring program or research method. To investigate new methodologies, the Alaska SeaLife Center initiated the CIBW Remote Monitoring pilot study in the summer of 2011. Observers used two robotically controlled video cameras mounted on a 9 m tower approximately 1.5 river miles from the confluence of the Little Susitna River Delta (within CIBW critical habitat). The remotely-captured behavioral information in this secluded location added finer-scale information about the habitat use and behavior to the existing body of knowledge about CIBW. Behaviors observed and video-recorded included typical beluga behaviors (e.g., travelling, milling, feeding suspected) along with a higher-than-anticipated frequency of other behaviors (e.g., breaching, spyhopping, mother/newborn interactions). Information on the interaction between harbor seals and belugas was also documented, with both species apparently foraging, in close proximity to one another. Remote video monitoring was demonstrated to be a valuable habitat-use assessment tool and the use of remote video monitoring in other areas in Upper Cook Inlet with similar physical qualities could be very beneficial to a more comprehensive understanding of the relationship between Cook Inlet belugas and their habitat.

### **A Study of the Environmental and Physical Factors that Influence the Movement and Survival of Beluga Whales in Cook Inlet, Alaska**

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The population of the endangered beluga whales in Cook Inlet (CI), Alaska, has been in decline over the past decades and no convincing explanation has been offered so far for this trend. Various environmental and hydrodynamic factors that may impact the belugas' movement and survival are analyzed. Satellite tracking of the beluga movements over a 5-year period is compared with local data such as river runoffs, water level and water temperatures, as well as with remote sensing data and hydrodynamic model simulations. It was found that the seasonal movement of the belugas within CI is correlated with the seasonal flow pattern of various rivers, suggesting that the availability of salmon and other fish in river mouths control the beluga's behavior. The annual counted numbers of beluga whales in CI, as well as the number of reported stranding events, both show interannual oscillations which resemble the Pacific Decadal Oscillation index, though the way that large-scale climatic variations may impact the beluga population is not yet understood. An interdisciplinary study is now underway to better understand the local and regional factors that impact the ecosystem and the environment that the belugas depend on for survival.

**First Noise Measurements of an Oscillator System for Drilled Shafts: Its Implications for the Endangered Cook Inlet Beluga Whale (*Delphinapterus leucas*)**

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The Knik Arm Crossing project is proposed to be built in Upper Cook Inlet, within critical habitat for the endangered Cook Inlet beluga whale (CIBW). Marine pile-driving produces high sound pressure levels that are often of concern for marine mammals. Alternatively, oscillator systems have been used to excavate and place piles for various bridge construction projects; until now, only qualitative assessments of the associated noise were previously available. In order to provide a quantitative assessment of the sound levels and potential impacts to CIBW, noise measurements were collected at the Gilmerton Bridge Replacement project in Chesapeake, Virginia, during the placement of large diameter (3.7 m) steel casings. Recordings of the oscillator system (Leffer VRM 3800) during operations were collected using a Cetacean Research CR-3 hydrophone and an M-Audio acoustic recorder (96 kHz sampling rate). The most noticeable noises' presumed to be associated with the oscillator - were transient, broadband, short tones at 15 kHz, and harmonics at 30 kHz and 45 kHz. Baseline ambient noise was measured at a distance of 30 m from the pile installation site; the mean rms SPL value was 115.9 dB re 1 uPa (SD = 0.4 dB). The mean rms SPL values for the oscillator were 121.6 dB re 1 uPa (SD = 6.4 dB) and 116.9 dB re 1 uPa (SD = 0.6 dB) at distances of 30 m and 300 m, respectively. Most of the oscillator noise dissipated near baseline with increased distance. Even if the frequency range of the oscillator overlaps with the hearing range of CIBW, the rapid dissipation of sounds over distance indicates that the oscillator represents a good mitigation solution. The noise measurements of this system are the first documented and provide baseline data for other environmental impact assessments where this method for drilling shafts could be used.

**Algal Toxins in Alaskan Marine Mammals: Assessing Current and Emerging Exposure Threats**

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Current climate trends are likely to expand the geographic range and duration of bloom-favorable conditions in northern regions, making algal toxins a growing concern in the Alaskan marine food web. Here we present data on the presence and distribution of two classes of algal toxins in a range of Alaskan marine mammal species. The first is domoic acid (DA), an emerging problem in Alaskan waters. This toxin is responsible for many cases of marine mammal death and illness in California and has recently been detected in marine mammals in Alaska. The second group of toxins are paralytic shellfish (PSP) toxins, a suite of toxins with a long history in Alaska. Many human illnesses and deaths have been reported over the past two hundred years, but there is little recorded information regarding effects of PSP toxins on Alaskan marine mammals. Sample material such as feces, urine, stomach contents, serum, and milk from stranded, subsistence harvested, and live-sampled animals were analyzed. Species represented include Steller sea lions, ice seals, northern sea otters, beluga whales, gray whales, and bowhead whales. Initial screening for DA and PSP toxins was performed using an ELISA screen followed by LCMS (for DA) or HPLC (for PSP toxins) confirmation. The overall goal of this project is to characterize the spatial and temporal patterns of algal toxin exposure in Alaskan marine mammal species in order to assess impacts on health, reproductive success, and mortality in marine mammal populations including those that are threatened, declining, and ESA-listed.

**Evaluation of Diet Composition and Plane of Nutrition of Free-Ranging Harbor Seals (*Phoca vitulina*) in Warm and Cool Climatic Periods**

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Oscillating cool and warm climatic periods have the ability to alter the basic structure and components of an ecosystem which can impact the dietary base of a predator. Changes to diet can have significant impacts on predator populations. A time series of harbor seal scat samples were collected from Tugidak Island, Alaska, during the summer from 2001 to 2009. Hard-part remains from scats were identified to the lowest possible taxon and approximate prey composition of the diet was determined from frequency of occurrence (FO) and biomass (BM) calculations. The nutritional profile of estimated diets was determined using a prey nutritional database developed from proximate analyses of various prey found in Alaskan waters. Diet profiles constructed by BM estimations appear to provide a more realistic representation of actual diets due to biases associated with FO data. The plane of nutrition was calculated by BM estimations; protein (13.47-17.49% of diet), lipid (1.57-4.90% of diet), and gross energy (0.65-1.37kcal/g of diet) of the average diet varied across collection years. Lipid content and gross energy of diets fluctuated within a collection year relating to pupping and molting periods. Further investigation into whether this variation corresponds to sea surface temperature anomalies observed in the Gulf of Alaska during this time period will occur. Combining the prey database and plane of nutrition across years provides insights regarding the role of nutrition in evaluating changes in pinniped populations. Identification of the components of harbor seal diets allows for detection of potential competition for fish resources.

**Serological Survey of *Leptosporosis* in Stranded Marine Mammals in Alaska**

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Leptospirosis cycles periodically, every 3-4 years, in pinnipeds along the California coast with seropositive rates ranging from 38.2-100% during an outbreak. Recent reports of positive marine mammal cases farther north along the Pacific coasts of Washington and British Columbia have been increasing which may be due to localized epizootics or wide dispersal of carrier animals from California. Since 1998, over 150 mammals handled through the Alaska SeaLife Center's stranding program have been routinely screened for antibodies to six leptospirosis serovars (*Leptospira bratislava*, *L. canicola*, *L. grippityphosa*, *L. hardjo*, *L. icterohemorrhagiae*, and *L. pomona*) using a microscopic agglutination microtiter procedure. Species have included seals, sea lions, walrus, and otters from numerous locations in Alaska. Positive antibody titers may develop for various reasons including acute disease, prior exposure, maternally derived antibodies, or cross reaction to antibodies to other disease. Titers have been overwhelmingly negative, with the first positive serological test result in 2003. Positive titers have been typically low or decrease on repeat testing and no animals tested exhibited clinical disease. Positive titers were most commonly to *L. hardjo*, *L. bratislava*, and *L. ictero* with *L. hardjo* also having the highest titers. There were few positive titers to *L. grippo*, and *L. pomona* and none for *L. canicola*.

**How "Resident" are Resident-Type Killer Whales in Alaska? New Data Show Both Localized and Widespread Movements**

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Piscivorous "resident" eco-types of killer whales have been studied using photo-identification methodology throughout Alaska, including southeastern Alaska (SEAK) and the Kenai Fjords-Prince William Sound (KF-PWS) region. Inclement weather and short days during fall and winter have restricted studies to summer and protected near-shore waters. Resident-type killer whale pods, designated AF and AG, have only been observed in SEAK and KF-PWS regions. The extent to which they range throughout the Gulf of Alaska was unknown, particularly in seasons other than summer, until 2010. Last year we reported on the 37-day movements of AF42, tagged with a satellite-linked transmitter in September 2010 in SEAK and documented travels to the Alaska Peninsula and Kodiak Island. In June 2011 we tagged AF18 in northern SEAK. Over the 42-day deployment the whale confined its range to coastal waters from Cape Fairweather to southern Baranof Island with most activity off the entrance to Cross Sound. In August 2011 we tagged two members of AG pod. Like AF42 in the fall of 2010, these whales remained in SEAK for a few days and then moved northwest following the shelf break until reaching Kodiak Island and remaining in its near-shore waters until the last transmissions. Given the 1700 km tracklines traveled by these whales to the west, it is clear that AF and AG pods range over a much larger area than previously thought. Our results suggest that movements between southeastern Alaska and Kodiak Island in the fall may be a consistent seasonal pattern.

**Are Western Steller Sea Lions Caught in a Predation-Driven Productivity Pit?**

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Data returns from Life History Transmitters (Horning & Hill 2005) implanted into 36 juvenile Steller sea lions (Horning et al. 2008) and released into the eastern Gulf of Alaska from 2005 through 2011 show high juvenile mortality from predation. Regional contemporary cumulative survival rates for ages 13-36 months (0.52, 95% c.i. 0.39-0.62) and for 13-60 months (0.48, 95% c.i. 0.39-0.53) remain below pre-decline estimates for the central Gulf (Holmes et al. 2007) of 0.75 and 0.64 respectively. At least 11 in 12 mortality events detected between ages of 1.4 and 4.1 years are attributed to predation (Horning & Mellish 2009). To evaluate the impact of such high levels of predation on juveniles we developed a conceptual, qualitative population model combining density dependent, age-specific predation rates with density independent causes of mortality. Of three modeled functional responses between sea lions and their predators, a type III sigmoid response was most consistent with available contemporary and retrospective demographic data. Within the model, a hypothesized density-dependent focus of predators on juvenile sea lions at intermediate abundances yields a greater effect on pup production through reduced recruitment (lowered by 50% from peak abundance) than through direct takes of adult females (increased by 5%). The type III model suggests that even without any changes in natality, high juvenile predation could effectively halve the population's reproductive potential through reduced female recruitment.

### **Autopsy from Space: Do Sleeper Sharks Prey on Live Steller Sea Lions?**

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Pacific sleeper sharks have been reported as potential predators of Steller sea lions. However, sleeper shark stomach contents collected near Steller rookeries revealed no evidence of sea lion tissue (Sigler et al. 2006). With jaw morphology suggesting suction feeding, only pups are thought to be taken live and consumption of older sea lions is suggested as scavenging. Here we report evidence of sleeper shark predation on a live four year old male Steller sea lion in the eastern Gulf of Alaska. Data transmitted post mortem from an intraperitoneally implanted, satellite linked Life History Transmitter shows a precipitous tag temperature drop from homeotherm body core temperatures near 37 to 5.5oC at time of death. In nine similar events detected in sea lions between the ages of 1 and 3 years the buoyant transmitters immediately sensed light and air, suggesting tag extrusion following sea lion dismemberment by a predator. Post mortem data from the 4 year old male shows the tag surrounded by cold, wet medium and without exposure to light. The tag first sensed light and air, and began transmissions 11 days post mortem. Regional sea surface temperatures at time of death ranged from 9-12oC, as confirmed by the tag at onset of transmissions. We interpret this data as traumatic death with immediate tag ingestion by a poikilotherm predator. Amongst known sea lion predators, killer whales and lamnid sharks have core temperatures elevated above ambient, and only sleeper sharks at depths below 100m are likely to have core temperatures below 10oC.

### **Soviet Catches of North Pacific Right Whales in the Eastern North Pacific**

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The eastern population of the North Pacific right whale (*Eubalaena japonica*) was recently estimated at about 30 individuals, making it one of the world's most critically endangered mammalian populations. This dire situation is a legacy of intensive historical whaling and illegal catches by the USSR in the 1960's. Newly discovered archival material consisting of formerly secret scientific, production and inspection reports from Soviet whaling fleets has provided details on the time and areas of sightings and catches of right whales, together with some rare biological data; these are summarized here. The reports show that during the period 1962-68 the USSR killed at least 514 right whales in the southeastern Bering Sea and the Gulf of Alaska (GOA), not 372 as previously thought. Positions are now available for many of the GOA catches, and reflect a broad offshore distribution in June, almost entirely outside areas surveyed in recent years. The sex ratio of catches made in 1963 was strongly male-biased (73%, 82/112 whales), and the great majority of whales (62/66 examined) were sexually mature. Many were large animals, with an overall length range of 9.7m to 19.8 m. Ten of 18 examined mature females were pregnant. The Soviets catches probably removed the bulk of the population, and surveys to assess the current abundance of right whales in the GOA (guided by these new data) are urgently needed.

### **Estimating Productivity and Pup Growth using Aerial Imagery of Harbor Seals on Ice**

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Monitoring indices of productivity and pup growth would lead to more timely management and better conservation of seal populations. But estimating even basic age structure of seal populations (pups vs. non-pups) is hampered by the difficulty of getting adequate numbers of measurements, particularly for species inhabiting areas of ice. A method to measure body size and estimate pup growth 'via remote sensing' would be valuable for long-term monitoring. We used vertical aerial photographs of harbor seals hauled out on glacial ice over two years at two sites (Disenchantment and Icy Bays, Alaska, USA) to estimate body length of seals (in a GIS; N = 30,383 seals over 49 surveys). We fit a linear growth curve to length measurements from a subset of pups (i.e., small seals photographed suckling; N = 1,018 mother-pup pairs), and then used independent data from known yearlings (N = 45) and discriminant analysis to discern pups (N = 9,692) from non-pups across the entire population. Because cross-sectional data tend to underestimate actual growth rates, we derived a novel correction to simulate measures of longitudinal growth. Our estimated growth (3.34 mm/day) did not differ by site or year, and was very close to results from an actual longitudinal study (3.30 mm/day; N = 7 pups). Productivity (pups/total seals) was similar across sites and years, varying from 0.34 to 0.40, but higher than estimated at other sites (0.23 - 0.34). This new method shows promise for estimating population structure and in turn pup growth and productivity, using regular aerial surveys.

### **Inter-Population Movements of Steller Sea Lions in Alaska**

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Based on genetics, Steller sea lions (SSL) have been divided into 2 populations ('east' and 'west') with the dividing line between populations at 144° W. These populations have had little exchange for thousands of years. During the past 15-30 years, the gap between breeding ranges of the populations has closed with the formation of new rookeries in the east, with founders from each population. Our study is based on >3000 SSLs marked as pups from 2000-2009 and resighted from 2000-2010. 107 (of 1995 marked) SSLs from the east were observed in the west; only 2 were females. 77 (of 2193 marked) from the west were observed in the east, with approximately equal numbers of each sex. Some males from each population travel to the opposite range, where they can remain for several years; most males eventually return to their natal population during the breeding season. SSL males typically cannot occupy breeding territories until age 9-10, so only the oldest of our marked males are capable of holding breeding territories. One western male occupied a breeding territory in the east; no eastern males were seen holding territories in the west. Eastern females almost never move west. In contrast, western females have traveled east, where at least 7 have given birth at eastern rookeries. New rookeries near the population boundary seem to have been driven by larger shifts in distribution of western females compared with eastern females.

### **Monitoring Seasonal Distribution of Cook Inlet Beluga Whales With Passive Acoustic Technology**

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Despite ongoing research, the seasonal distribution of Cook Inlet beluga whales (CIB) (*Delphinapterus leucas*) remains somewhat enigmatic. Until recently, virtually all scientific data came from summer aerial surveys (~10 days in duration) and what little was known of winter distribution came from several satellite tagged CIB that were monitored prior to their endangered listing under the ESA.

We began a collaborative study in 2008 that aimed to establish the seasonal presence of CIB throughout Cook Inlet by using passive acoustic monitoring packages containing Ecological Acoustic Recorders (EARs) and echolocation click detectors (C-PODs). Since then, mooring packages have been deployed at 10 sites to monitor for CIB presence. At the 2011 Alaska Marine Science Symposium, we reported on preliminary analyses of data collected which showed that CIB were detected in upper and mid-inlet sites, but not the lowermost inlet, and that CIB presence did not appear consistent across months. Also, ambient noise (e.g. water flow, shipping traffic, and industrial activities) varied among locations and often masked beluga calls.

We continued our monitoring efforts in 2011 and present the most up to date results in our poster.

### **Paired Heart Rate and Dive Data for 46 Consecutive Days on a Free-Ranging Harbor Seal (*Phoca vitulina*)**

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Energy balance is a key component of survival. A great deal of marine mammal research examines components of energy balance such as diet, disturbance or movements. Field measurements of heart rate (HR) can be used to predict relatively fine-scale activity-specific energy expenditure in free-ranging animals. To acquire paired measurements of activity and HR, a subadult female harbor seal was fitted with a time depth recorder (TDR) and a HR monitor that collected data from 2 May to 16 June, 2009 in Endicott Arm, Alaska. During this period 226 haulouts, 8,974 individual dives, 411 dive bouts, and 185 non-haulout surface periods were characterized. Haulouts, defined as periods with TDR salinity readings =248, lasted  $\bar{x}=54\pm 7$ mins (range 1-523mins). Average HR during haulouts was  $\bar{x}=88\pm 7$ bpm (36-140bpm). Resting HR, defined as the minimum 5min average HR during haulouts lasting =5mins, was  $\bar{x}=80\pm 2$ bpm (47-137bpm). During dives, HR is suppressed and the relationship between measurable energy expenditure and HR becomes disconnected. Consequently, diving HR was grouped into dive bouts, which included measurements during sequential dives <9mins apart, the inter-dive surface periods, and a corresponding 9 min post dive-bout recovery period. Dive bouts lasted  $\bar{x}=91\pm 7$ mins (9.2-914mins). HR during haulout periods, non-haulout surface periods and dive bouts will be presented. These data will ultimately be used to predict activity-specific energy expenditure for free-ranging harbor seals, particularly in relation to vessel traffic.

**Effects of Hot-Iron Branding on the Endocrine and Immune Profiles of Steller Sea Lion (*Eumetopias jubatus*) Pups**

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Steller sea lions (*Eumetopias jubatus*) (SSL) are the largest otariids, with the western distinct population segment currently listed as endangered under the Endangered Species Act. Due to conservation concerns there has been extensive research focused on this species and assessing population demographics and trends requiring permanently marked individuals. Identifiable individuals allow researchers to track vital rates such as pup production, age-specific survival, and mortality rates. However, the short term (<180 min) effects of hot-iron branding on endocrine and immune profiles has not been previously explored in SSL pups during the early post natal period. Therefore, the aim of the present study was to assess the short term effect of hot-iron branding on endocrine and immune profiles of SSL pups (male=7, female=11) ranging in age between 9 and 28 days old.

Following hot-branding, cortisol concentrations ( $p=0.036$ ) significantly decreased while aldosterone concentrations decreased but not significantly ( $p=0.069$ ). Thyroid hormone concentrations were not affected by hot-iron branding. Further, circulating immune components including total and differential white blood cell counts and in vitro proliferation of peripheral blood mononuclear cells were not altered following hot-iron branding ( $p=0.064$ ). However, cortisol and aldosterone concentrations were negatively correlated with the elapsed time between researchers' arrival on the rookery and blood collection. These findings are suggestive that the hot-iron branding did not cause additional changes in endocrine and immune parameters beyond those following the initial rookery disturbance associated with research activities.

**The Ties that Bind: Resident Killer Whale Social Structure Before and After the Exxon Valdez Oil Spill**

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Photo-identification data of Prince William Sound (PWS) resident killer whales (*Orcinus orca*) collected from 1984-1993 were examined using social network analysis methods. The social dynamics amongst community members were evaluated in the context of one of the worst environmental disasters in United States history: the Exxon Valdez oil spill. Twenty-two whales, from a sample of 103 individuals, died within five years of the spill. Networks derived from this sample modeled the social structure of the community pre- and post-spill, and the influence of age class and sex on the variation in network measures was assessed. Individual whales were expected to assume different social roles within the society, determined in part by age class and sex, and mortalities incurred after the spill were expected to result in a deterioration of social cohesion. Results suggest that certain individuals were more central to the network, with age class potentially contributing to the centrality of a whale. The removal of these whales affected individual associations, as well as the overall social structure of the community. Post-spill whales had more associations that were weaker in strength, compared to their pre-spill counterparts. The network, as a result, became less connected and more dispersed, indicating a disintegration of community cohesiveness. PWS resident killer whales rely on established relationships for survival, and a disruption of their social structure might have implications for the fitness of the entire population.

**Expanding Perspectives, Investigating Pod Specific Killer Whale Habitat  
with ARGOS satellite Telemetry**

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We attached 34 "LIMPET" SPOT5 location-only satellite tags to resident (fish-eating) killer whales from 2004-2011. Tags were applied to the dorsal fin with a crossbow and held by two 4mm diameter x 6.5cm long titanium darts. Transmission time ranged from 1 to 76 days; average was approximately 26 days. Resident killer whales were tracked for a total of 70,000 km over 850 days with an average cumulative daily distance traveled of 82km. Individuals in 12 different pods were tagged with multiple attachments across years and seasons for some pods. Movements and home range varied considerably between pods; e.g. two of the tagged pods ranged between the lower Kenai Peninsula and southeastern Alaska while one pod never left Prince William Sound. Pods tended to maintain consistent home ranges between years. There were differences in movements between pods of the two population haplotypes (SR and NR); whales of the SR haplotype tended to stay more nearshore. Using fixed kernel density estimators, we determined important habitat for each pod and the population. Frequently used areas included Montague Strait, lower Knight Island Passage, and Hinchinbrook Entrance (Prince William Sound); the area northeast of Kodiak Island; the area northwest of Kayak Island and outer Resurrection and Aialik Bays. In September 2011 we deployed a new depth-transmitting tag, showing that whales can frequently make deep dives between 250 and 400 m, lasting 3 to 8 min. Dive data will be used to examine feeding behavior in the different areas.

**A General Modelling Framework for Animal Movement and Migration using Multi-State Random Walks**

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Recent developments in animal tracking technology have permitted the collection of detailed movement paths from individuals of many species. Despite this increasing wealth of information, model development for the analysis of movement data has not kept pace with these technological advancements. This is largely due to the inherent complexity of the movement process and the structure of animal location data, which often include considerable observation error in both time and space. Sophisticated statistical models of both the movement and observation process are therefore required to facilitate reliable inference. To better understand complicated animal movements in heterogeneous landscapes, we propose that movement paths can be dissected into a few general movement strategies among which animals transition as they are affected by changes in the internal and external environment. We develop a suite of state-space models of individual animal movement based on mixtures of biased and correlated random walks that include different behavioural states for oriented, exploratory, and area-restricted movements. Models may then be "custom-built" for a wide variety of species applications, thereby allowing the simultaneous estimation of time allocations to latent movement behaviour states, state transition probabilities, locations of foraging or resident centres of attraction, and the strength of attraction (or repulsion) to specific locations. Using reversible jump Markov chain Monte Carlo methods to facilitate Bayesian model selection and multimodel inference, we apply the proposed methodology to harbor seal movements among haul-out and foraging locations in Cook Inlet, Alaska.

### **What Can Individual Cook Inlet Beluga Whales Tell Us About the Habitat Use of the Population and Exposure to Potential Threats?**

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Habitat use and social structure are among the information needed to better understand Alaska's endangered Cook Inlet beluga whale (CIBW; *Delphinapterus leucas*) population, identify population threats, assess cumulative effects, and contribute to recovery. A photo-identification catalog was developed to "track" individually-identified whales throughout Upper Cook Inlet (UCI). The 2005-2010 catalog contains records for 270 individuals identified from right-side photographs taken during 472 group encounters. CIBW occurrence and movements among subsections of UCI were examined. Coefficients of associations (COAs) among individuals were calculated for those whales resighted in every year of the study. Although results are preliminary, we did not find evidence of structure in CIBW groups photographed in UCI in terms of location, individual associations, color, or age-class. None of the identified belugas were found in groups that were comprised of solely white or gray animals, and all were found in groups that contained calves. Calves and neonates were seen in all subsections of UCI. Records of CIBWs resighted in all years of the study indicated that whales moved among all subsections of UCI. Some potential anthropogenic threats (e.g., from pile driving, sewage discharge, shipping lanes, in-water seismic activity, military exercises) to CIBWs are localized within subsections of UCI; however, because most, and perhaps all of the individuals in the CIBW population move throughout UCI, they are likely to encounter multiple potential threats. The cumulative effects of exposure to multiple stressors should therefore be considered when addressing CIBW recovery.

### **Significance of Whale Predation on Natural Mortality Rate of Pacific Herring**

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By examining humpback whale interactions with three wintering herring population (Prince William Sound, Lynn Canal and Sitka Sound) we determined that humpback whales had the greatest impact on Prince William Sound Herring. The number of whales was greatest in Prince William Sound; they foraged on herring for a longer period of time into the winter, and removed a greater percentage of the available biomass of herring. Whales in Lynn Canal foraging on herring peaked in fall; whale numbers dropped off considerably after October. Whales in Sitka Sound were more abundant than Lynn Canal but they foraged predominately on krill, even though the Sitka herring population is far more robust than the other populations. The herring biomass consumed in Prince William Sound approximated the biomass lost to natural mortality over winter as projected by age structured stock assessments, suggesting they are the dominant top down force in herring removals, at least for the years covered. These data indicate that the focused predation in Prince William Sound can exert top down controlling pressure, but whale populations are not a ubiquitous threat to forage fish populations in other regions at this time.

### **Spatial and Temporal Distribution of Cook Inlet Beluga Whales in the Little Susitna River Delta**

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Beluga whales prefer near shore, estuarine habitats through the summer, migrating into deeper water for the winter. Cook Inlet belugas, recently designated an endangered species, display similar migration patterns using the terminal branches of Upper Cook Inlet as their summer habitat of choice. This area has been included as critical habitat for this species, although it is directly adjacent to Anchorage, the largest population center and shipping corridor in Alaska. Understanding the habitat features driving usage patterns by beluga whales in this area is crucial for the conservation of this steadily declining species. The Little Susitna River Delta is thought to be an important summer foraging, mating, and calving habitat area for Cook Inlet belugas. Land based observers on Fire Island, AK have observed beluga presence in this area but distance from the observation station has prevented detailed spatial distribution and behavior data collection. The Alaska SeaLife Center Cook Inlet Beluga Remote Monitoring program is a pilot project to study the efficacy of video monitoring for beluga whales in the Little Susitna River Delta. Observers used two robotically controlled video cameras mounted on a 9 m tower approximately 1.5 river miles from the confluence of the Little Susitna River and the waters of Cook Inlet. Belugas were observed through the cameras during the months May to August, 2011 entering the river mouth and traveling upstream past the camera site. Detailed group composition, distribution, and duration of sighting data was collected, proving both the effectiveness and value of this monitoring method.

### **Monitoring Reproductive Hormones in Captive Adult Female Steller Sea Lions during a Breeding Program**

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The Western stock of Steller sea lions (SSLs) is listed as endangered, and the Eastern stock listed as threatened. Although information about adult females is necessary to understanding the population, handling of wild adult females in the U.S. is currently limited. Captive studies on adult female SSLs can provide valuable linear information applicable to the wild population. The Alaska SeaLife Center (ASLC) is conducting a project investigating reproduction and maternal investment in four captive adult female SSLs housed at ASLC. One portion of this project includes monitoring changes in hormones across the reproductive cycle in our captive female animals. We are validating new assays for analyzing reproductive hormones such as estradiol (E2) and progesterone (P4) in SSL serum using commercially available kits. These new assays provide a method for determining hormones in serum that are quicker and easier than previous methods such as radio-immunoassays (RIA) because they use non-hazardous materials and do not require pre-assay serum extraction. Tests for spiking, parallelism, and comparisons to an outside laboratory using RIA have shown these assays to be reliable and effective for assessing hormones in SSL serum. Preliminary data also suggests that these methods may be more sensitive than RIA.

### **Agent-Based Modeling of Mammal-Eating Killer Whales and their Prey: Not Your Lynx-Hare Cycle**

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The role of mammal-eating killer whales *Orcinus orca* in the decline of various marine mammal populations in Alaska is controversial and potentially important in their recovery. We developed an agent-based model of killer whales with plausible energetics and behavior, calibrated and validated the model against published expectations for killer whale consumption rates, group dynamics and demography, and explored the emergent properties of single-prey and 3-prey models using small, abundant "seals" as primary prey, a generic small population of "sea lions" and seasonally available "whales" the single-prey model gave results that were intuitively responsive to underlying parameters, but were sensitive to killing rates, similar to classical predator-prey models. The dynamics showed long time lags (~ 30 years) between troughs of prey and predator numbers and highly variable predator age structure. In scenarios where the importance of seasonally available whales was manipulated, the large whales had the potential to augment killer whale numbers somewhat, but had minimal effect on the dynamics of either predators or alternate prey. Perturbing the carrying capacity of primary, small prey created strong shifts in killer whale population size and consequent indirect effects on alternate prey. No predictive inference is suggested for these models due to the absence of more realistic elements (e.g., explicit prey-switching, more realistic prey structure) than we used, but the models do suggest that we expect more complicated dynamics than have thus far been considered in discussions of transient killer whales and their prey.

### **Acoustic Monitoring of Cook Inlet using a Cabled Bottom-Mounted Array System**

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The upper Cook Inlet, near Anchorage, Alaska, is host to an endangered beluga whale population (*Delphinapterus leucas*), spurring interest in whether passive acoustic monitoring can be used to characterize their acoustic environment and detect the presence of animals. Unfortunately, the inlet provides a hostile environment to underwater acoustic gear, including strong tidal currents, large tidal ranges, and debris-filled waters. In Sept./Oct. 2011 a real-time bottom-mounted cabled hydrophone system was installed off Pt. Woronzof, Anchorage, to determine whether such a system could provide adequate monitoring of the anthropogenic and biological acoustic contributions off Anchorage. The cabled array was divided into two subarrays spaced 500 m apart. Each subarray had two hydrophones spaced 3 m apart, sampled at 96 kHz each, permitting bearings of individual sounds to be obtained from two spatially-separated locations. In addition, a four-channel directional vector sensor was attached to the end of the system to help characterize the non-acoustic noise contributions to the system, and investigate whether strong directional noise sources could be nulled. Visual observers on an overlooking 40 m cliff documented the bearing and range of beluga and anthropogenic activities within 4 km of the array. The evolution of the ambient noise and flow noise characteristics measured during the three-week deployment will be discussed, along with a variety of clean sounds of aircraft, ships, activities from the Port of Anchorage, and beluga vocalizations. [Work supported by the Ocean Foundation and SAExploration]

**Experimental Demonstration of Passive and Acoustic Decoys for Reducing Sperm Whale Depredation**

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Sperm whales depredate deep-water sablefish longline fisheries in the Gulf of Alaska, and this behavior continues to expand throughout SE Alaska. Over the past decade the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP), a collaborative effort between fishermen, scientists, and fisheries managers, has honed visual and passive acoustic techniques for studying the mechanics of sperm whale depredation and testing potential depredation reduction strategies, including the deployment of buoyline decoys without the associated fishing gear. Limited tests of "passive" decoys by SEASWAP on sperm whales have shown promise. In Aug. 2011 the first test of an "acoustic" decoy was conducted off Sitka, AK. Recordings of fishing vessel sounds known to attract whales were installed on an autonomous playback device, and then attached to a decoy buoyline. A volunteer fishing vessel deployed the instrumented buoyline in the presence of three sperm whales, including one individual (GOA-026, aka "Jack the Stripper"), who is a known serial depredator across multiple years. Autonomous acoustic recorders were also attached to the decoy to monitor the presence/absence of the animals. The vessel then deployed an actual halibut set 10 km further away along the continental shelf break and hauled the following morning, once the acoustic decoy had activated. Two whales remained by the decoy; however, "Jack" attempted to reach the true gear, but arrived only after 75% of the gear had been hauled. Both acoustic and visual observations of the test are reviewed.

**Intestinal and Respiratory Parasites in Juvenile Steller Sea Lions (*Eumatopias jubatus*)  
from Prince William Sound, Alaska**

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Numerous internal parasites have been reported in Steller sea lions (*Eumatopias jubatus*) and, while some have been associated with severe disease and mortality (Stroud 1978, Zabke 2004), low to moderate parasite burdens appear to exist in most otherwise healthy individuals (Fay 1982, Rausch 1964). Between April 2003 and June 2011, a total of 65 juvenile Steller sea lions were captured at several different locations in Prince William Sound. The sea lions were held in temporary captivity for up to 12 weeks at the Alaska SeaLife Center as part of multiple research projects. Routine health screening of these animals included periodic microscopic examination of feces and tracheal mucous for parasites and parasite ova using direct smears as well as centrifugation of samples. Relative numbers and types of parasites were recorded for each sample. Photomicrographs and/or preserved parasites were submitted to board certified veterinary parasitologists to aid in classification. These tests confirmed the presence of a variety of trematodes, cestodes, nematodes and arachnids both at capture and throughout the captive periods for most of the sea lions but no adverse health effects were noted.

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**Evaluation of Harbor Porpoise (*Phocoena phocoena*) Population Decline in Southeastern Alaska Inland Waters**

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Since the early 1990s, the National Marine Mammal Laboratory (NMML) has been conducting shipboard sighting surveys in southeastern Alaska inland waters from Icy Strait/Glacier Bay to Clarence Strait to investigate cetacean ecology, distribution and abundance. Sampling design and data collection of cruises conducted in 1991-93, 2006, 2007 and 2010 followed standard line-transect methodology, allowing for the computation of harbor porpoise abundance in the region. Population trends ( $r$ ) for the whole study area and selected sub-areas of historical concentrations were assessed from these estimates with a Bayesian exponential model. Results indicated an overall decline ( $r = -2.0\%$ , 95% probability interval [PI] =  $-4.1\%/+2.8\%$ /year, probability of decline [PD]=88%) in southeastern Alaska inland waters. Regional trend estimates indicated that harbor porpoise abundance decreased in Icy Strait and Glacier Bay ( $r = -0.5\%$ /year, 95% PI= $-4.3\%/+5.9\%$ /year, PD=59%), but more pronounced declines were observed in the southern range of the survey area, near Wrangell ( $r = -2.8\%$ /year, 95% PI=  $-5.6/+3.0\%$ /year, PD=90%) and in Frederick Sound ( $r = -4.1\%$ /year, 95%PI=  $-6.0/+1.1\%$ /year, P.d=95%). The reasons for the negative trends are not well understood and could include bycatch, a change in prey distribution, a decrease in survival or shift in distribution due to habitat degradation, predation, or a combination of these factors. It is noteworthy that a greater decline was observed in areas where gillnet and purse-seine fisheries exist.