ALASKA MARINE SCIENCE SYMPOSIUM

JANUARY 25-29, 2016

HOTEL CAPTAIN COOK & EGAN CENTER • ANCHORAGE, ALASKA

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

E. Siddon

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2016 Alaska Marine Science Symposium
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The 2016 AMSS Keynote and Plenary speaker abstracts
are presented in chronological order

Posters are grouped by day per Wave category

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Keynote

Arctic Executive Steering Committee - One Year on Report From the Executive Director

Mark Brzezinski
Executive Director of the U.S. Government's
Arctic Executive Steering Committee

Former United States Ambassador to Sweden Mark Brzezinski serves as Executive Director of the U.S. Government's Arctic Executive Steering Committee. On January 21st, 2015, in recognition of the unique challenges and opportunities presented by the Arctic, President Obama issued an Executive Order to enhance coordination of national efforts in the Arctic. The Executive Order creates expanded opportunities for Alaskans and those in the Federal government to work on Arctic issues and establishes a clear structure to improve the coordination of Federal Arctic activity.

An Arctic Executive Steering Committee (AESC) was established to oversee implementation of the National Strategy for the Arctic Region (https://www.whitehouse.gov/blog/2015/03/27/white-house-releases-implementation-report-national-strategy-arctic). The AESC convenes at the Deputy Secretary level to guide the development of department and agency plans to assure that Federal activity is well-coordinated and better communicated to partners such as the State of Alaska, Alaska Native communities, the U.S. Congress, the business community, international partners, and other stakeholders. Dr. John Holdren, Assistant to the President for Science and Technology and Director of the White House Office of Science and Technology Policy, serves as the AESC Chair.

As U.S. Ambassador to Sweden between 2011-2015, Mark worked closely with the Swedish Government during its Chairmanship of the Arctic Council. The U.S. is one of eight member nations of the Arctic Council, and currently is the Council's Chair. In May 2013, Mark joined the U.S. Delegation led by Secretary of State John Kerry to the Arctic Council Ministerial in Kiruna, Sweden, above the Arctic Circle. At that ministerial, key agreements involving Arctic search and rescue, oil spill preparedness and cleanup, and inclusion of non-Arctic nations as Arctic Council observers were advanced. In September 2013, Mark welcomed President Barack Obama to Stockholm for a historic, first ever visit by a sitting U.S. President to Sweden's capital. In Stockholm, President Obama and all five heads of government of the Nordic countries met together to discuss a shared approach to climate change and the future of the Arctic among other issues. Mark made the Arctic a central focus of his tenure in Sweden. Speaking in February 2015 at Dartmouth College where he gave the Montgomery Fellowship lecture on the Arctic, Mark noted that "the Arctic is simultaneously a strategic problem and a human problem." At the U.S. Embassy, he developed new partnerships with government and diplomats, business, media and entertainment, and the environmental and NGO community to consider the link between what is happening in the Arctic and what is happening in the rest of the world. He used new communications and social-media tools to share how the looming crisis confronting the Arctic is a tangible preview of the crisis confronting the world as a whole. Mark initiated and helped develop the new U.S. Fulbright Scholarship devoted to the study of the future of the Arctic. The new Arctic Fulbright, funded by the State Department, is a unique two-year program composed of researchers selected from the eight Arctic Council countries. Mark served on the National Security Council staff under President Clinton between 1999-2001, first as Director for Russia and Eurasia, then as Director for the Balkans.

Mark received his undergraduate degree at Dartmouth College, his law degree at the University of Virginia Law School and has Doctorate in political science from Oxford University. He was a Fulbright Scholar in Warsaw, Poland between 1991-1993. He was a partner at a Washington, DC law firm before joining the Obama Administration, and is a member of the Council on Foreign Relations.

Keynote

Persistent Record-high Temperatures in the North Pacific in 2014/2015: a Climate Hypothesis


Photo: Georgia Institute of Technology

Emanuele Di Lorenzo
School of Earth & Atmospheric Sciences
Georgia Institute of Technology
Email: edl@eas.gatech.edu

Emanuele Di Lorenzo is a professor of ocean and climate sciences at the Georgia Institute of Technology. Trained as a coastal physical oceanographer and modeler at Scripps (2003 Ph.D.), Di Lorenzo's work now focuses on developing observationally-constrained theories and models to explain large-scale ocean and climate changes. He conducts interdisciplinary research on diagnosing the climate impacts on regional and coastal marine ecosystems, particularly in the Pacific Ocean (e.g. www.pobex.org). Di Lorenzo is active in international organizations such as CLIVAR, PICES and ICES.

In PICES, he is co-chair of WG27 on North Pacific climate variability and change. He is also a member of the Phenomena, Observations and Synthesis panel in US CLIVAR. More recently, Di Lorenzo has expanded his interdisciplinary research interests towards modelling social-ecological-environmental systems.

Keynote

Four Decades of Change: An Arctic Seabird Responds to a Warming Arctic

George Divoky
Director, Friends of Cooper Island
Email: divoky@cooperisland.org


Photo: cooperisland.org

George Divoky has studied Alaskan seabirds since 1970 when he participated in censuses of marine birds and mammals in the Beaufort and Chukchi seas. In 1975 he began a study of Black Guillemots, a diving seabird, on Cooper Island, 35 km east of Point Barrow, Alaska, that he still maintains. The study, starting its fifth decade, is the longest continuous seabird study in the Arctic. The time series of data on phenology, breeding success, diet, and adult survival provided some of the first examples of the biological consequences of snow and sea ice reductions in the Arctic and continues to track the major environmental changes now occurring in the region.

Divoky has also worked for federal and state agencies on a range of Alaskan seabird management and conservation issues including the Alaska Native Land Claims Settlement Act, oil and gas exploration of the outer continental shelf, oil spill damage assessment and restoration, and regional climate change. He is currently Director of Friends of Cooper Island a Seattle-based nonprofit organization working to analyze the observations from Cooper Island and ensure their continuation in coming decades.

Divoky's research on the Black Guillemots of Cooper Island was featured in a cover story in the New York Times Magazine entitled "George Divoky's Planet," in the PBS's Scientific American Frontiers program "Hot Times in Alaska" with Alan Alda, and on ABC Nightly News and Nightline. He has appeared on The Late Show with David Letterman, and has been interviewed on NPR's Talk of the Nation and Science Friday. His research and experiences on Cooper Island were featured in *Greenland*, a play about climate change staged by the Royal National Theatre in London in 2011.

Divoky was born and raised in Cleveland, Ohio, has Bachelor's and Master's degrees from Michigan State University and a doctorate from the University of Alaska Fairbanks.

Keynote

Blue Mind: Changing the Way We Think About Water

Wallace J. Nichols
Scientist, author, consultant, educator, entrepreneur
Email: info@wallacejnichols.org


Photo: waterstep.org

Scientist Wallace "J." Nichols, author of the New York Times best-selling *Blue Mind*, will present cutting-edge neuroscience research about the benefits of being in, on, or simply near water. He will also describe his personal experiences with successful communication efforts related to the crucial importance of our connection to water that engaged people in problem-solving around ocean issues. In addition to being a scientist and author, Nichols is a wild water advocate, movement-maker, and dad. His research and expeditions have taken him to coasts and waterways across North, Central and South America, to Asia, Africa, Australia, and Europe. This is what keeps his colleagues and collaborators working hard to understand and restore our blue planet. He is a Research Associate at California Academy of Sciences and co-founder of Ocean Revolution, an international network of young ocean advocates; SEE the WILD, a conservation travel network; Grupo Tortuguero, an international sea turtle conservation network; and Blue Mind Fund, reconnecting people to water.

His research interests span ocean and aquatic ecosystems, migratory species, marine protected areas, fisheries management, and plastic pollution with special emphasis on building new action networks. He has authored and co-authored more than 200 scientific papers, articles, and reports and his work has been broadcast on NPR, BBC, PBS, CBS' *This Morning*, Discovery Channel, National Geographic and Animal Planet as well as featured in *Time, Newsweek*, *GQ*, *Outside Magazine*, *Fast Company*, *Scientific American,* and *New Scientist*, among others.

Keynote

Imaging the Arctic: Communicating Climate Science Through Art

Kristin Laidre* and Maria Coryell-Martin**
*University of Washington
Polar Science Center, Applied Physics Laboratory
Email: klaidre@uw.edu

**Expeditionary Art
542 N. 74th St.
Seattle, WA 98103
Email: maria@expeditionaryart.com


Photo: NOAA


Photo: BlackBurge Art

Kristin Laidre is a marine biologist at the University of Washington's Polar Science Center, Applied Physics Laboratory, and the School of Aquatic and Fishery Sciences. She is partially supported by the Greenland Institute of Natural Resources in Nuuk. Her research is field-based and is focused on studying the behavior, ecology, and population dynamics of Arctic marine mammals. She is a member of the IUCN Species Survival Commission Polar Bear Specialist Group and the IUCN Species Survival Commission Cetacean Specialist Group. She has published over 80 peer-reviewed scientific papers and co-authored 2 books on Arctic marine mammals.

Maria Coryell-Martin is an expeditionary artist following the tradition of traveling artists as naturalists and educators. She graduated from Carleton College in 2004 and received a Thomas J. Watson fellowship to explore remote regions through art from 2004-2005. Since then, Maria has worked with scientists, local communities, and expeditions in Alaska, Canada, Greenland, and the Antarctic Peninsula. In the field, Coryell-Martin sketches with ink and watercolor, and collects multimedia recordings to build her palette of place, a record of experience, climate, and color. This work is the basis for exhibits of large-scale studio and field paintings, as well as multimedia presentations and hands-on workshops for audiences of all ages to promote observation, scientific inquiry, and environmental awareness

Plenary Sessions - Tuesday, January 26

Plenary Sessions: Tuesday, January 26 -- Arctic Ocean

TIME	TITLE	PRESENTER	SECTION
8:00 - 8:15 AM	Closing the Mass Budget between Bering Strait and the Arctic Basin: The Chukchi Slope Current	Robert Pickart	Climate and Oceanography
8:15 - 8:30 AM	Ocean Acidification in the Pacific-Arctic Boundary Regions	Jeremy Mathis	Climate and Oceanography
8:30 - 8:45 AM	Surface Currents on the Northeastern Chukchi and Western Beaufort Sea Shelves	Rachel Potter	Climate and Oceanography
8:45 - 9:00 AM	Time Series of Currents and Water Masses on the Chukchi Shelf	Carol Ladd	Climate and Oceanography
9:00 - 9:15 AM	Dissolved and Particulate Trace Metal Concentrations in Sea Ice at Oliktok Point, Alaska	Vincent Domena *	Climate and Oceanography
9:15 - 9:30 AM	Variability of Flow, Nutrients and Chlorophyll in the Chukchi Sea	Calvin Mordy	Lower Trophic Levels
9:30 - 10:00 AM	**BREAK**		
10:00 - 10:15 AM	Biological Influence and Impact of Oil Spills in Ice Covered Waters	Kyle Dilliplaine *	Lower Trophic Levels
10:15 - 10:30 AM	What Lies Beneath the Ice: Using Sea Ice as a Driver of Benthic Communities in the Alaska Arctic	Alexandra Ravelo *	Lower Trophic Levels
10:30 - 10:45 AM	Long-term Changes in Summer Zooplankton Communities of the Western Chukchi Sea, 1945-2012	Elizaveta Ershova *	Lower Trophic Levels
10:45 - 11:00 AM	Juvenile Growth and Lipid Dynamics of Arctic cod (*Boreogadus saida*) and other Alaskan Gadids Under Variable Environments	Benjamin Laurel	Fishes and Fish Habitats
11:00 - 11:15 AM	Plan for Monitoring Bottom Fish Communities in the Beaufort Sea	Brenda Norcross	Fishes and Fish Habitats
11:15 - 11:30 AM	Population Dynamics of Arctic cod (*Boreogadus saida*) in the Eastern Chukchi Sea	Jennifer Marsh *	Fishes and Fish Habitats
11:30 - 1:00 PM	**BREAK - LUNCH ON YOUR OWN**		

* Masters; ** Doctorate

Plenary Sessions: Tuesday, January 26 -- Arctic Ocean

TIME	TITLE	PRESENTER	SECTION
1:00 - 1:15 PM	Pink Salmon as Sentinels for Climate Change in the Arctic	Ed Farley	Fishes and Fish Habitats
1:15 - 1:30 PM	Seabirds Signal Short-term Patterns and Long-term Trends in Oceanographic Variability of the Eastern Chukchi Sea	Adrian Gall	Seabirds
1:30 - 1:45 PM	Interannual Variability in Seabird Communities with Respect to Prey and Environmental Properties in the Northern Bering and Chukchi Seas	A. Catherine Pham *	Seabirds
1:45 - 2:00 PM	Spring Field Metabolic Rates and Behaviors of Adult Female Polar Bears on the Sea Ice of the Southern Beaufort Sea	Anthony Pagano *	Marine Mammals
2:00 - 2:15 PM	Unexpected Presence of Transient Killer Whales in Kotzebue Sound	Manuel Castellote	Marine Mammals
2:15 - 2:30 PM	Marine Mammal Distribution and Habitat in the Eastern Chukchi Sea Observed from a Slocum Ocean Glider	Mark Baumgartner	Marine Mammals
2:30 - 3:00 PM	**BREAK**		
3:00 - 3:15 PM	Oceanographic Characteristics Associated with Bowhead Behaviors in the Chukchi Sea	John Citta	Marine Mammals
3:15 - 3:30 PM	Best Practices for Community-Based Monitoring: Observing Alaska's Coasts and Oceans	Marilyn Sigman	Human Dimensions
3:30 - 3:45 PM	The Uncertainties of Sea Ice: Socio-legal Dynamics in a Changing Arctic Ocean-scape	Kristen Shake *	Human Dimensions
3:45 - 4:15 PM	Predictable Wind Forced Upwelling Can Lead to a Favorable Feeding Environment for Bowhead Whales in Nearshore Waters	Carin Ashjian	Ecosystem Perspectives
4:15 - 4:30 PM	The Arctic Marine Pulses Model: Linking Contiguous Domains in the Pacific Arctic Region	Sue Moore	Ecosystem Perspectives
4:30 - 4:45 PM	Interannual Variability and Change in an Arctic Ecosystem: Can We Separate a Signal from the Noise?	Robert Day	Ecosystem Perspectives
4:45 - 5:00 PM	A Northeastern Chukchi Shelf Ecosystem Observatory: Year 1 Results and Year 2 Build-out	Seth Danielson	Ecosystem Perspectives
		* Masters; ** Doctorate	
6:00 - 7:15 PM	**POSTER SESSION - Wave 1**		
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Plenary Session Abstracts

Tuesday, January 26

Closing the Mass Budget Between Bering Strait and the Arctic Basin: The Chukchi Slope Current

Robert Pickart
Woods Hole Oceanographic Institution, rpickart@whoi.edu
Bryce Corlett
Woods Hole Oceanographic Institution, bcorlett@whoi.edu

After passing through Bering Strait, Pacific-origin water flows across the Chukchi Sea in different branches that ultimately exit the shelf and provide heat, freshwater, and nutrients to the interior basin. It is important, therefore, to understand where and by what mechanisms the water is fluxed offshore. We have compiled all known shipboard hydrographic sections occupied across the Chukchi shelfbreak and slope that include direct velocity measurements (shipboard ADCP or lowered ADCP). In all there are 46 sections that were occupied during the months of May-October from 2002 to 2014, spanning the region from Barrow Canyon to approximately 168° W. The data reveal the presence of a heretofore unknown surface-intensified, westward-flowing current over the continental slope situated offshore of the eastward-flowing shelfbreak jet. We call this feature the Chukchi slope current, which exists under all wind conditions. The basic characteristics and variability of the current are described. Using this information plus previously published transport values in Bering Strait and the Beaufort shelfbreak jet, we attempt to close the mass budget of the Chukchi shelf. The mean heat transport of the Chukchi slope current during the summer months is estimated, which has the potential to melt a substantial amount of pack-ice in the Canada Basin and influence the geographical distribution of the ice melt.

Ocean Acidification in the Pacific-Arctic Boundary Regions

Jeremy Mathis
NOAA, Office of Oceanic & Atmospheric Research Headquarters, jeremy.mathis@noaa.gov
Jessica Cross
NOAA, Pacific Marine Environmental Laboratory, jessica.cross@noaa.gov
Wiley Evans
Pacific Marine Environmental Laboratory, wiley.evans@noaa.gov
Natalie Monacci
University of Alaska Fairbanks, nmonacci@alaska.edu

The continental shelves of the Pacific-Arctic Region (PAR) are especially vulnerable to the effects of ocean acidification (OA) because the intrusion of anthropogenic CO_2 is not the only process that can reduce pH and carbonate mineral saturation states for aragonite (Ω_{Arag}). Enhanced sea-ice melt, respiration of organic matter, upwelling and riverine inputs have been shown to exacerbate CO_2-driven ocean acidification in high-latitude regions. Additionally, the indirect effect of changing sea-ice coverage is providing a positive feedback to OA as more open water will allow for greater uptake of atmospheric CO_2. Here, we compare model-based outputs from the Community Earth System Model with a subset of recent ship-based observations, and take an initial look at future model projections of surface water Ω_{Arag} in the Bering, Chukchi and Beaufort Seas. We then use the model outputs to define benchmark years when biological impacts are likely to result from reduced Ω_{Arag}. Each of the three continental shelf seas in the PAR will become undersaturated with respect to aragonite at approximately 30-year intervals, indicating that aragonite undersaturations gradually progress upstream along the flow path of the waters as they move north from the Pacific Ocean. However, naturally high variability in Ω_{Arag} may indicate higher resilience of the Bering Sea ecosystem to these low-Ω_{Arag} conditions than the Chukchi and the Beaufort Seas. Based on our initial results, we have determined that the annual mean for Ω_{Arag} will pass below the current range of natural variability in 2025 for the Beaufort Sea and 2027 for the Chukchi Sea. Because of the higher range of natural variability, the annual mean for Ω_{Arag} for the Bering Sea does not pass out of the natural variability range until 2044. As Ω_{Arag} in these shelf seas slips below the present-day range of large seasonal variability by midcentury, it could put tremendous pressure on the diverse ecosystems that support some of the largest commercial and subsistence fisheries in the world.

Surface Currents on the Northeastern Chukchi and Western Beaufort Sea Shelves

Rachel Potter
University of Alaska Fairbanks, rapotter@alaska.edu
Ying-Chih Fang
University of Alaska Fairbanks, yfang2@alaska.edu
Hank Statscewich
University of Alaska Fairbanks, hstatscewich@alaska.edu
Thomas Weingartner
University of Alaska Fairbanks, tjweingartner@alaska.edu
Peter Winsor
University of Alaska Fairbanks, pwinsor@alaska.edu

High-resolution high-frequency radar (HFR) measurements of surface currents during the open water season in the northeastern Chukchi Sea and, more recently, the western Beaufort Sea have revealed enormous spatial and temporal complexity in the surface circulation. This variability is associated with the Alaskan Coastal Current within Barrow Canyon and its interaction with the flow over the western Beaufort Sea shelf, as well as eddies and fronts over the Chukchi Sea shelf.

In the Chukchi, HFR suggests a front along 71.5°N, that likely separates summer Bering Sea water from ice meltwater that has not been entirely flushed from the region. North of the front the water column is heavily stratified, and the circulation is typically weaker and more variable in direction than the more easterly (and less stratified) flow south of this latitude. This eastward flow feeds central shelf waters toward Barrow Canyon and appears to persist even under westward winds that are <6 m/s. Moored data suggest that the HFR measurements reflect flow throughout the water column in unstratified areas, while in heavily stratified regions, the HFR velocities are a good proxy for flow in the upper 20 m of the water column occupied by the meltwater.

At the juncture of the Chukchi and Beaufort seas the northeastward Alaskan Coastal Current flow emanating from the Chukchi shelf interacts with the typically westward flow on the Beaufort shelf to form a number of complex circulation features. These often include an anticyclonic eddy offshore of Cape Simpson where historical observations indicate that bowhead whales often feed. The eddy may aggregate zooplankton and thus enhance the feeding efficiency of bowheads in this region.

Time Series of Currents and Water Masses on the Chukchi Shelf

Carol Ladd
NOAA, Pacific Marine Environmental Laboratory, carol.ladd@noaa.gov
Phyllis Stabeno
NOAA, Pacific Marine Environmental Laboratory, Phyllis.Stabeno@noaa.gov
Calvin Mordy
University of Washington, Calvin.W.Mordy@noaa.gov
Sigrid Salo
NOAA, Pacific Marine Environmental Laboratory, sigrid.a.salo@noaa.gov

Beginning in 2010, moorings have been deployed by NOAA's Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI) program at nine mooring sites on the Chukchi shelf and slope. Data from the moorings, combined with satellite-tracked drifter trajectories and hydrographic transects are used to examine flow patterns, transport, and water masses on the eastern Chukchi shelf. Transport past Icy Cape accounts for ~40% of the transport through Bering Strait. Maximum monthly-mean transport (> 0.8 Sv) occurs in July with low interannual variability, while the weakest monthly transports are in December – April with high interannual variability. Currents are significantly correlated with alongshore winds. Drifters deployed near Bering Strait exhibit on-shelf flow at Central Channel, while drifters deployed near Icy Cape typically exit the shelf via Barrow Canyon and travel westward along the slope.

While flow along the Alaskan coast is typically northeastward toward Barrow Canyon, reversals do occur. During flow reversals, Atlantic Water (AW) (temperature > -1°C; salinity > 33.6) has been observed to upwell from deeper than 200 m in the Arctic Basin onto the Chukchi Shelf via Barrow Canyon. Most observations of AW on the Chukchi shelf have been in or near Barrow Canyon; observations of AW farther onto the shelf are rare. Despite mooring location on the shelf ~225 km from the head of Barrow Canyon, three AW events have been observed during three winters of moored observations at mooring C1 (70.8°N, 163.2°W). In addition to increases in temperature and salinity, the AW events are associated with southwestward winds and currents, changes in sea-ice cover, and increased nutrient concentrations in the bottom water. The first AW event (Oct/Nov 2010) was observed near the ice edge during ice advance while the other two events were associated with polynyas, suggesting that both latent and sensible heat mechanisms may be important to the formation and maintenance of some Chukchi Sea polynyas. These data were collected mainly as part of three BOEM funded projects (CHAOZ, CHAOZ-Extension and ArcWEST).

Dissolved and Particulate Trace Metal Concentrations in Sea Ice at Oliktok Point, Alaska

Vincent Domena
University of Alaska Fairbanks, vadomena@alaska.edu
Ana Aguilar-Islas
University of Alaska Fairbanks, amaguilarislas@alaska.edu
Robert Rember
University of Alaska Fairbanks, rrember@iarc.uaf.edu

The formation of sea ice in the fall and subsequent melt in the spring are important to the biogeochemistry of trace metals in Polar seas. In the Arctic, sea ice that forms over the shallow shelves can entrain sediment during formation, impacting the trace element concentrations in the water column not only during growth, but also upon melting. When sea ice that formed over shelves becomes part of the pack ice, it has the potential to release its sediment load on the broad shelves but also may be transported into the Arctic Basins during the melting season. To determine the trace metal content of Arctic land fast ice, samples were collected from Oliktok Point, Alaska in May 2015. Here we present for the first time dissolved (0.2 µm filtrate) and particulate (>0.2 µm size pore filter) trace metal concentrations from the water column and from ice cores collected using a new trace metal clean ice corer designed specifically for this study. Fifty cores were collected from five locations (10 cores each) near the mouth of the Colville River. The dissolved concentrations of trace metals in the melted ice cores were relatively constant among stations, while particulate trace metal concentrations were highly variable, likely as a result of the high spatial variability in sea ice sediment inclusions. Particulate concentrations of select metals were further separated into either the leachable (in 25% acetic acid) or recalcitrant fractions (acid digested) as a means of assessing potential availability to biota. Preliminary data will be discussed in the context of the role of sea ice in the biogeochemistry of Arctic shelf waters.

Variability of Flow, Nutrients, and Chlorophyll in the Chukchi Sea

Calvin Mordy
University of Washington, mordy@uw.edu
Phyllis Stabeno
NOAA, Pacific Marine Environmental Laboratory, phyllis.stabeno@noaa.gov
Carol Ladd
NOAA, Pacific Marine Environmental Laboratory, carol.ladd@noaa.gov
Lisa Eisner
NOAA, Alaska Fisheries Science Center, lisa.eisner@noaa.gov

The Chukchi Sea contains several distinct water masses which flow through Bering Strait, and is influenced by seasonal and interannual swings in ice thickness and extent. These processes affect the nutrient flux, and the timing, extent and distribution of primary production. Integrated data from several sources were used to examine patterns of flow and the variability of nutrients, chlorophyll and production across the shelf. Data was collected during the past 6 years (2010-2015) through multiple field programs (CHAOZ, CHAOZ-Extension, ArcWEST, EIS, RUSALCA, and Ocean Exploration), and includes satellite-tracked drifters (drogued at ~30 m), moorings, and data from hydrographic surveys and autonomous platforms. Drifter trajectories, EIS and repeat hydrographic lines between Bering Strait and Barrow Canyon delineate the pattern of flow and the boundary between the nutrient-poor Alaska Coastal Current, and the nutrient-rich water to the west (Bering Sea Water and Anadyr Water). In the bottom water, nutrient replenishment occurs on event time scales throughout the winter concurrent with increasing salinity. In spring, chlorophyll fluorescence increases along the bottom during ice retreat, most likely due to the deposition of ice algae. Associated with this event is a temporary decrease in PAR, a decrease in nitrate concentrations and oxygen supersaturation. In summer, subsurface chlorophyll maxima were common in the eastern Chukchi Sea. In the western Chukchi Sea, nutrient rich Anadyr Water had chlorophyll concentrations an order of magnitude higher than east of 168°W, and silicate limitation was occasionally observed.

Biological Influence and Impact of Oil Spills in Ice Covered Waters

Kyle Dilliplaine
University of Alaska Fairbanks, kbdilliplaine@alaska.edu
Marc Oggier
University of Alaska Fairbanks, moggier@alaska.edu
Eric Collins
University of Alaska Fairbanks, recollins@alaska.edu
Hajo Eicken
University of Alaska Fairbanks, hajo.eicken@gi.alaska.edu
Bodil Bluhm
University of Tromso, bodil.bluhm@uit.no
Rolf Gradinger
Institute of Marine Research, rolf.gradinger@imr.no

Recent media attention has focused on the decision of Royal Dutch Shell to withdraw from its oil leases in the Alaskan Chukchi Sea. Despite this decision, the risk of an oil spill occurring in the vicinity of sea ice remains high as maritime activities in Alaska's ice covered seas are projected to continue rising concurrent with the increase of summer waters partially covered by sea ice. Oil encapsulation and migration through the brine channel system in sea ice poses significant risk to the ice-associated biological community which supports the Arctic food web. Extracellular Polymeric Substances (EPS), generated by ice-associated microbes and algae, can inhibit exchange of brine with underlying seawater; this process prevents desalination of growing ice and creates a more porous ice microstructure. To simulate an under-ice oil spill, experimental mesocosms were designed to grow sea ice from artificial seawater which was inoculated with biological cultures collected from land-fast sea ice in Barrow, AK. Small scale infiltration and distribution of Alaskan North Slope crude oil in sea ice and its impact on sea ice biota was investigated over two experimental runs (spring 2014, 2015). Three biological replicate cores were collected at each sampling event (5 cm diameter corer), 2 days prior (2OR) and 10 days post-oil release (OR10), from each tank along with one core collected for salinity measurements. Algal biomass was allowed to reach low levels before release of oil under the ice simulating both an oil layer (OL) and mechanical dispersion of oil into an oil emulsion (OE). Oil released into tanks arrested algal growth regardless of treatment type; phaeophytin to chlorophyll *a* ratios suggests that cell death occurred after release. EPS concentrations decreased after oil release in the OE and OI treatments while increasing in the basal ice layer of the biological control tank. Hydraulic pressure generated through oil layer thickness may play a more important role in oil percolation within sea ice than EPS influences on microstructure. Results from this study will help to direct future research needs into the fate of sub-ice oil spills and the impact on the associated sea ice community.

What Lies Beneath the Ice: Using Sea Ice as a Driver of Benthic Communities in the Alaska Arctic

Alexandra Ravelo
University of Alaska Fairbanks, amravelo@alaska.edu
Brenda Konar
University of Alaska Fairbanks, bhkonar@alaska.edu
Jacqueline Grebmeier
University of Maryland, jgrebmei@umces.edu
Andrew Mahoney
University of Alaska Fairbanks, armahoney@alaska.edu

On many Arctic continental shelves, benthic organisms can be found in high abundance and biomass. These benthic communities are dominated by certain taxa over large spatial scales and are structured by environmental drivers that can also vary spatially. Spatial and temporal changes in sea ice can influence salinity and water column productivity that subsequently influence the quality and quantity of food deposited to the benthos. The impact that sea ice variables (e.g., ice cover, persistence of the ice edge, and the phenology of ice retreat and growth) may have on Arctic benthic communities is largely unknown. The main objective of this analysis was to evaluate the relation between spatial changes in benthic community composition, biomass, and feeding guilds with spatial changes in the seasonality of sea ice. Benthic community data from 103 stations were gathered throughout the Alaska Beaufort and Chukchi Sea shelves. Passive microwave sea ice concentration data, obtained from the National Snow and Ice Data Center, were used to compute variables meant to reflect the seasonality of sea ice. Statistical results indicated that very few significant linear correlations occurred between the number of benthic taxa, total station biomass, and each of the sea ice variables evaluated for both the Chukchi and Beaufort Sea shelves. Multivariate analysis resulted in moderate correlations with Chukchi Sea infauna and epifauna community biomass, as well as high correlations with Beaufort Sea epifauna community biomass. The same variables selected as community drivers had lower correlations with benthic community feeding guilds. The inclusion of sea ice variables to the traditionally used environmental variables (temperature, salinity, sediment type, etc.) resulted in more significant correlations with benthic community biomass. Due to its coarse resolution and insensitivity to ice thickness and snow depth, the passive microwave-derived sea ice data is a poor predictor of sympagic-benthic coupling. Moreover, many of the environmental changes relevant to benthic communities are hard to record *in situ* year round. However, the seasonality of sea ice advance and retreat, that is well captured by passive microwave data, integrates many environmental changes and can therefore be used as another driver of benthic community variability.

Long-term Changes in Summer Zooplankton Communities of the Western Chukchi Sea, 1945-2012

Elizaveta Ershova
University of Alaska Fairbanks, eershova@alaska.edu
Russell Hopcroft
University of Alaska Fairbanks, rrhopcroft@alaska.edu
Ksenia Kosobokova
Shirshov Institute of Oceanology, xkosobokova@ocean.ru
Kohei Matsuno
Hokkaido University, k.matsuno@fish.hokudai.ac.jp
John Nelson
University of Victoria, jnelson@uvic.ca
Atushi Yamaguchi
Hokkaido University, a-yama@fish.hokudai.ac.jp
Lisa Eisner
NOAA, National Marine Fisheries Service, Lisa.Eisner@noaa.gov

The Chukchi Sea pelagic ecosystem, which is finely tuned to the seasonal ice formation and retreat, has been experiencing dramatic oceanographic change related to shifting sea ice cover and increasing temperatures over the last decades. We examine historical datasets on zooplankton communities in the central Chukchi Sea during the time period spanning 1946-2012. Analysis is confounded by differences between years in terms of spatial coverage, seasonal variability, and methodology; nonetheless, trends remain detectable when a sufficient number of study years are compiled. In addition to high levels of inter-annual variability, we demonstrate significant increases in zooplankton biomass and abundance in recent years compared to historical studies, as well as shifting distribution ranges for several key species. This signal is most pronounced within the copepods, particularly *Calanus glacialis*, which appears to be indirectly benefiting from warming of the region. While summer zooplankton communities of the Chukchi Sea have been primarily Bering-Pacific in character for as long as our records exist, continuing warming and ice loss are increasing the influence of Bering-Pacific fauna within the Chukchi region.

Juvenile Growth and Lipid Dynamics of Arctic Cod (*Boreogadus saida*) and Other Alaskan Gadids Under Variable Environments

Benjamin Laurel
NOAA, Alaska Fisheries Science Center, ben.laurel@noaa.gov
Louise Copeman
Oregon State University, lcopeman@coas.oregonstate.edu
Mara Spencer
NOAA, Alaska Fisheries Science Center, mara.spencer@noaa.gov
Paul Iseri
NOAA, Alaska Fisheries Science Center, paul.iseri@noaa.gov

The thermal sensitivity of Arctic fish species is poorly understood, yet such data is a critical component of forecasting ecosystem impacts of climate change. In a multi-year study, we used experimental and field approaches to examine temperature- and food-sensitivity in growth, survival and lipid allocation for juvenile stages of two Arctic gadids (Arctic cod, *Boreogadus saida* and saffron cod, *Eleginus gracilis*). Comparisons were also made with two North Pacific gadids (walleye pollock, *Gadus chalcogrammus* and Pacific cod, *Gadus macrocephalus*) across multiple temperatures in the laboratory. Among the Arctic gadids, Arctic cod had a narrow thermal tolerance (stenothermic) with a growth advantage at low temperatures (< 3 °C) whereas saffron cod had a broad thermal tolerance (eurythermic) with a growth advantage at higher temperatures; i.e., 12 – 16 °C. However, laboratory and field samples indicated saffron cod had lower lipid content than Arctic cod across all thermal environments and ontogenetic stages. Under mesothermal conditions (5 – 12 °C), growth and lipid density was higher in walleye pollock and Pacific cod than Arctic gadids, but energy storage was limited to the liver (and consequently larger juveniles) and required significantly higher consumption rates to achieve. Collectively, these data suggest that: 1) saffron cod are more resilient to warming than Arctic cod but are lower quality prey items and 2) the ecological relevance of North Pacific gadids in the Arctic will be determined by both temperature and productivity.

Arctic - Fishes and Fish Habitats

Plan for Monitoring Bottom Fish Communities in the Beaufort Sea

Brenda Norcross
University of Alaska Fairbanks, bnorcross@alaska.edu
Brenda Holladay
University of Alaska Fairbanks, baholladay@alaska.edu

Fish communities in the Arctic may be indicators of change that might occur due to climate and oil and gas exploration. An initial benchmark is generally established by sampling a set of sites in multiple years sequentially to estimate interannual variability. Standard practice is to conduct one trawl haul per station. Establishing the annual frequency of sampling and minimum number of hauls per station necessary to detect changes in demersal fish communities is essential to designing a monitoring program. Using small bottom trawls, we assessed interannual variability of bottom fish communities between 2013 and 2014 in the eastern U.S. Beaufort Sea at eight depths, 20–1000 m, on each of four transects. To determine if one haul per station was representative of a site, replicate hauls were made along one transect at the U.S.–Canada border in 2014. The similarity among replicate hauls between years and within a single year was excellent, indicating a stable fish community. There were distinctly different bottom fish communities on the Beaufort Sea shelf (20–100 m) and slope (200–1000 m). Shelf communities had higher abundances of smaller fishes; whereas slope communities had fewer, but larger, individuals. There was no change in fish abundance between years, but there was interannual variability in the biomass of fish communities on the slope. However, as few fishes were captured at deep stations, the difference between catching and not catching a single large heavy fish affected relative biomass significantly, which may distort the conclusion of interannual variability. Furthermore, these replicate hauls occurred in the eastern Beaufort Sea, which appears to have fewer fish species and in lower abundance than the western Beaufort Sea; the similarity within replicates may not be as striking in a more diverse environment. The stability in this region of the Arctic, indicates it is likely sufficient to forego replicate fish sampling at a station in one year and season, and sequential years of sampling in that season, when characterizing bottom fish communities within a long-term study of community stability.

Population Dynamics of Arctic Cod (*Boreogadus saida*) in the Eastern Chukchi Sea

Jennifer Marsh
University of Alaska Fairbanks, jmmarsh@alaska.edu
Franz Mueter
University of Alaska Fairbanks, fmueter@alaska.edu
Terrance Quinn II
University of Alaska Fairbanks, terry.quinn@alaska.edu

Currently, commercial fishing is prohibited in the US Arctic due to insufficient data to assess the sustainability of potential fisheries. In the 2009 Arctic Fisheries Management Plan (FMP) by the North Pacific Fishery Management Council, Arctic cod (*Boreogadus saida*) was identified as one of three potential target species. A preliminary assessment of Arctic cod was completed for the Arctic FMP based on bottom trawl surveys that occurred in 1990 and 1991 in the northeastern Chukchi Sea. During August/September of 2012 and 2013, two comprehensive fisheries oceanographic standardized grid surveys were conducted with stations spaced every 30 nautical miles throughout the U.S. Chukchi Sea. Arctic cod were sampled by surface trawl, bottom trawl (2012 only) and acoustic surveys. Age 1+ Arctic cod were ubiquitous throughout the region, in low abundances, while age-0 occurred mainly in the north with high abundances. We will present a simple Leslie Matrix model using updated life history parameters, and recent survey data to better understand the status of Arctic cod in the eastern Chukchi Sea. We will present model sensitivity to varying input parameters, such as natural mortality and recruitment. Overall, the Leslie Matrix model was a convenient tool for synthesizing information on this data poor stock.

Pink Salmon as Sentinels for Climate Change in the Arctic

Ed Farley, Jr.
NOAA, Alaska Fisheries Science Center, Ed.Farley@noaa.gov
Kristin Cieciel
NOAA, Alaska Fisheries Science Center, kristin.cieciel@noaa.gov
Jeanette Gann
NOAA, Alaska Fisheries Science Center, Jeanette.Gann@noaa.gov
Wess Strasburger
NOAA, Alaska Fisheries Science Center, wes.strasburger@noaa.gov

Pink salmon (*Onchorhynchus gorbuscha*) are not a new occurrence in the Arctic, yet over the past decade their relative abundance appears to be increasing. For instance, during 2008 the subsistence catch of adult pink salmon in Elson Lagoon near Barrow was relatively high compared to previous years. Relatively large catches of adult pink salmon in the Arctic are unusual, the questions are: 1) what conditions led to the high abundance (marine survival) of these salmon; and 2) can their favorable response be measured in ways that link to variability in sea ice, water temperature, salinity, and or prey availability? We address these questions by examining recent information on ecosystem function and fish response collected during integrated ecosystem surveys in the Chukchi Sea in 2007, 2012 and 2013.The surveys occurred during late summer, August through September. Relative abundance of juvenile pink salmon was high in the Chukchi Sea during 2007 and low in 2012 and 2013.Because pink salmon spend one year in the ocean before returning to spawn, the relatively high juvenile pink salmon abundance during 2007 could have been an indicator of high marine survival that year resulting in larger adult returns one year later (2008).Therefore, to understand if pink salmon can be used as a sentinel to climate change in the Arctic, we will compare relative abundance, size, energetic status, and diet of juvenile pink salmon among the three years and determine if these changes relate to sea ice variability, temperature, salinity, and zooplankton biomass.

Seabirds Signal Short-term Patterns and Long-term Trends in Oceanographic Variability of the Eastern Chukchi Sea

Adrian Gall
ABR, Inc., agall@abrinc.com
Tawna Morgan
ABR, Inc., tmorgan@abrinc.com
Robert Day
ABR, Inc., bday@abrinc.com
Arny Blanchard
University of Alaska Fairbanks, alblanchard@alaska.edu

Processes and responses to environmental change by marine ecosystems often are challenging to quantify because they are hidden under water. Seabirds offer visible evidence of the productivity of marine ecosystems. We studied the community of seabirds at-sea in the eastern Chukchi Sea to improve our understanding of interactions between the biotic and abiotic components of the marine environment. Repeated sampling of systematic transects in the northeastern Chukchi Sea during the ice-free seasons of 2008–2013 showed that the community consisted of ~40 species and was dominated numerically by planktivorous seabirds. Seabird abundance varied by up to two orders of magnitude among years, and birds generally were more abundant in September than August. Despite these interannual and seasonal variations in abundance, the community's species-composition was similar among years. The associations of seabirds with habitat characteristics varied with foraging method and preferred prey. Pursuit-diving species were more abundant in warm, weakly stratified water, whereas surface-feeding species were more abundant in cold, strongly stratified water. Planktivorous seabirds were more abundant near thermal surface fronts, whereas omnivores were more abundant far from fronts. Comparisons of data from this recent period with data from historical surveys (1975–1981) indicated that the seabird community shifted from one consisting primarily of piscivorous seabirds to one consisting primarily of planktivorous seabirds. This shift suggests that zooplankton prey are more accessible now to avian predators as seasonal ice cover has declined. Advective processes that transport oceanic zooplankton from the Bering Sea to the Chukchi Sea, together with the local effects of sea ice, strongly influence the distribution of seabirds, particularly the planktivorous species. This multispecies and multidisciplinary study provides a benchmark to assess the ecological consequences of anthropogenic activity against the backdrop of climate change that is affecting the Chukchi Sea.

Interannual Variability in Seabird Communities with Respect to Prey and Environmental Properties in the Northern Bering and Chukchi Seas

A. Catherine Pham
Hawai'i Pacific University, apham4@my.hpu.edu
K. David Hyrenbach
Hawai'i Pacific University, khyrenbach@hpu.edu
Kathy Kuletz
U.S. Fish and Wildlife Service, kathy_kuletz@fws.gov
Ed Farley
NOAA, Alaska Fisheries Science Center, Ed.Farley@noaa.gov
Lisa Eisner
NOAA, Alaska Fisheries Science Center, lisa.eisner@noaa.gov
Alexei Pinchuk
University of Alaska Fairbanks, aipinchuk@alaska.edu

The ongoing loss of sea ice in the Arctic is predicted to lead to environmental changes in the region, including increased human activities. Managers need a baseline understanding of the ecosystem to assess the potential impacts of such changes. The Arctic Ecosystem Integrated Survey project surveyed the physical and chemical oceanography, plankton, fish, and seabirds of the northern Bering and Chukchi seas in late summer of 2012 and 2013. Pacific Arctic sea ice cover during the preceding winters was less extensive in 2012 than in 2013, but its spring retreat from the region in 2013 was earlier and more uniform. These differences are expected to have bottom up effects on ecosystem structure since sea ice influences water mass properties and stratification. In 2012, the study area can generally be characterized as being cooler and saltier, and having higher nutrient and chlorophyll-a concentrations, higher zooplankton biomass, and less forage fish biomass compared with 2013. Seabird communities appeared to shift too; for example, in 2012, auklets were more northerly and more abundant, while shearwaters were more offshore and less abundant compared with 2013. These interannual differences allowed us to investigate how spatial associations between seabirds, their prey, and their habitat change under different environmental conditions. Specifically, we aimed to identify the factors that influence seabird community structure on an interannual basis. First, we defined seabird communities and their prey-habitat associations using a nonmetric multidimensional ordination, which produced a two dimensional result that explained 91.1% of the variance in the data with a stress of 12.09. The dimensions appeared to represent two habitats that were distinct in geographic location, prey abundance, chlorophyll-a concentration, physical properties, and bathymetry. The strongest correlations were with latitude, longitude, bathymetric depth, salinity, and chlorophyll-a. A multi-response permutation procedure grouped by year and geographic region (northern Bering Sea, southern Chukchi Sea, northern Chukchi Sea), for a total of six year-region combinations, revealed significant interannual differences in seabird community structure. Based on these analyses,

seabird communities appear to be structured by ecotones that change in location interannually, with environmental properties being somewhat more important than prey abundance.

Spring Field Metabolic Rates and Behaviors of Adult Female Polar Bears on the Sea Ice of the Southern Beaufort Sea

Anthony Pagano
U.S. Geological Survey, Alaska Science Center, apagano@usgs.gov
George Durner
U.S. Geological Survey, Alaska Science Center, gdurner@usgs.gov
Todd Atwood
U.S. Geological Survey, Alaska Science Center, tatwood@usgs.gov
Stephen Atkinson
Government of Nunavut, Department of Environment, sveveone@mymts.net
Daniel Costa
University of California, Santa Cruz, costa@ucsc.edu
Terrie Williams
University of California, Santa Cruz, tmwillia@ucsc.edu

Recent declines in sea ice have been linked to reductions in body condition, survival, and population of polar bears (*Ursus maritimus*) in some Arctic regions. Reduced availability of ice seals are presumed to be the cause of these declines, but increases in energy expenditure associated with changing sea ice conditions may be an additional mechanism. Field metabolic rates of polar bears are unknown and little quantitative data exist on polar bear behaviors and foraging demands on the sea ice. We quantified the metabolic rate, feeding rate, behavior, and foraging success of 7 wild adult female polar bears over 8–11 days during the spring of 2014 and 2015 on the southern Beaufort Sea pack ice using doubly-labeled water and GPS-equipped video camera collars. Polar bears had metabolic rates 1.3 × predictions from allometric equations and 1.3–1.6 × greater than previously predicted for polar bears. Activity budgets derived from video camera collars corroborated differences in metabolic rates among individuals and bears spent 71% of daylight hours resting. Foraging success varied with 3 bears successfully killing and eating ringed seals, while the remainder either scavenged from old carcasses or fasted. Our results suggest polar bears have high energy demands that will limit their ability to behaviorally adapt to forecasted declines in Arctic sea ice.

Arctic – Marine Mammals

Unexpected Presence of Transient Killer Whales in Kotzebue Sound

Manuel Castellote
NOAA, Alaska Fisheries Science Center, manuel.castellote@noaa.gov
Kate Stafford
University of Washington, stafford@apl.washington.edu
Robert Small
Alaska Department of Fish & Game, bob.small@alaska.gov
Alex Whiting
Kotzebue IRA, alex.whiting@qira.org

Prior to the mid-1980s, belugas were seen in Kotzebue Sound regularly during spring and summer, often in large numbers, and provided an important subsistence resource. Over the last ~30 years, sightings declined sharply, indicating a substantial reduction in beluga seasonal presence and distribution. During the summer of 2013, a passive acoustic monitoring study began with the primary objective to describe the seasonal and geographic occurrence of acoustically detected belugas, and secondarily, killer whales and harbor porpoises. We deployed 3 acoustic moorings, covering the social communication band 0- 12.5 kHz and the echolocation band 20-160 kHz. The moorings were deployed on July in a line south of Cape Krusenstern, northwestern Kotzebue Sound, with a detection range from shore south ~7 miles to monitor cetaceans traveling in nearshore waters. Automatic detectors were applied to process the recordings and all detections were manually validated. All three moorings were recovered on September, and cetaceans were detected at each site on the large majority of the 67 days monitored. Belugas were only detected on 3 days (9 and 25 July, and 19 August), whereas killer whales and porpoises were detected nearly every day (59 and 66, respectively) at each site. Beluga detections were comprised only of echolocation signals, and the absence of social calls and whistles may be an acoustic response towards a silent behavior in the presence of their primary predator, transient killer whales; acoustic activity of captive and wild belugas decreases or even ceases in their presence, likely to avoid detection by these predators, and thus possibly represents a survival strategy. Killer whales detections were primarily echolocation signals limited to very short click trains, double clicks, and single clicks, a known acoustic behavior for transient killer whales when targeting prey. Therefore, our results suggest the presence of transient killer whales in prey searching mode concurrent with belugas in silent mode (or not present) to avoid being detected by predators. This high rate of transient killer whale detection is uncommon and was unexpected, and the implication relative to the decrease in belugas is intriguing and uncertain.

Marine Mammal Distribution and Habitat in the Eastern Chukchi Sea Observed from a Slocum Ocean Glider

Mark Baumgartner
Woods Hole Oceanographic Institution, mbaumgartner@whoi.edu
Kate Stafford
University of Washington, stafford@apl.washington.edu
Hank Statscewich
University of Alaska Fairbanks, hstatscewich@alaska.edu
Peter Winsor
University of Alaska Fairbanks, pwinsor@alaska.edu

The Arctic is home to a diverse group of marine mammals that are highly adapted to survive in difficult environmental conditions, but basic information about the oceanographic processes and features that govern marine mammal distribution is sorely lacking. The Arctic poses particular challenges to at-sea marine mammal research that hinder our efforts to study the relationship between animal distribution and oceanographic conditions, including notoriously poor weather and underdeveloped port facilities. To address these challenges, we have developed the capability to simultaneously monitor marine mammal occurrence (via passive acoustics) and oceanographic conditions with autonomous Slocum ocean gliders. Building on successful short (< 11 days) pilot projects in 2013 and 2014, we deployed a single Slocum glider in the southern Chukchi Sea 100 km north of the Bering Strait during July 2015. Using an onshore-offshore zigzag track that covered 1070 km over the course of 2 months, the glider surveyed past Kotzebue (Cape Krusenstern), Point Hope, Cape Lisburne, Point Lay, Icy Cape, and was recovered 90 km due west of Wainwright in September. The glider observed strong variability in temperature, salinity, and current speed associated with the Alaska Coastal Current (inshore) and the more quiescent Bering Sea water (offshore). Marine mammals were detected in both real-time and after review of archived recordings from the glider. Of particular interest was the detection of subarctic species, including humpback, fin, and several occurrences of killer whales. Numerous ship passages were detected. Analyses of these recently collected data will focus on changes in species community composition with location (north/south Chukchi Sea) and water mass, as well as associations between species occurrence and fronts. We plan to repeat this survey annually for the next 5 years to investigate trends in occurrence and distribution of Chukchi Sea marine mammals that coincide with changes in oceanographic conditions.

Oceanographic Characteristics Associated with Bowhead Behaviors in the Chukchi Sea

John Citta
Alaska Department of Fish & Game, John.Citta@alaska.gov
Stephen Okkonen
University of Alaska Fairbanks, srokkonen@alaska.edu
Lori Quakenbush
Alaska Department of Fish & Game, Lori.Quakenbush@alaska.gov
Wieslaw Maslowski
Naval Postgraduate School, maslowsk@nps.edu
Robert Osinski
Naval Postgraduate School, roberto@iopan.gda.pl
John "Craig" George
North Slope Borough, Craig.George@north-slope.org
Robert Small
Alaska Department of Fish & Game, Bob.Small@alaska.gov
Harry Brower
North Slope Borough, harry.brower@north-slope.org
Mads Peter Heide-Jorgensen
Greenland Institute of Natural Resources, mhj@ghsdk.dk
Lois Harwood
Fisheries and Oceans Canada, Lois.Harwood@dfo-mpo.gc.ca

Each fall, bowhead whales in the Bering-Chukchi-Beaufort (BCB) population migrate westward from summering grounds in the Beaufort Sea through the Chukchi Sea to the northern coast of Chukotka, Russia. The Chukchi Sea is of interest to the petroleum industry and industrial activity may coincide, both spatially and temporally, with the westward migration. The path of migration varies annually and whales often pause to feed. To investigate inter-annual variability in the fall migration, we fit behavioral state-space models to whale locations obtained during 2006-2012 from 35 bowhead whales and classified locations as associated with lingering behavior (presumably feeding) or directed travel. We examined how locations associated with lingering were distributed annually and determined the oceanographic features associated with the whales' path of travel and behavioral state in 2008 and 2009, two years for which we have oceanographic results from a pan-arctic coupled ice-ocean model. We observed two patterns in migration. The first pattern, observed in 2006, 2008, and 2010, was characterized by a high density of lingering locations near Barrow, Alaska, and along the coast of Chukotka, Russia. Whales generally did not linger in the central Chukchi in these years. The second pattern, observed in 2009 and 2012, was characterized by a high density of lingering locations in the north-central Chukchi. Using oceanographic results from 2008 and 2009, we found that whales generally followed water characterized by temperatures < 0° C and salinities 31.5–34.5 psu. Bowhead whales avoided Alaska

Coastal Water and Siberian Shelf Water (the latter of which defined the western limit of their range) likely due to lower intrinsic densities of zooplankton prey. Along their tracks, whales were more likely to linger in areas characterized by stronger gradients in bottom salinity. Variation in the location of water masses largely explained differences in where whales crossed the Chukchi Sea.

Best Practices for Community-Based Monitoring: Observing Alaska's Coasts and Oceans

Marilyn Sigman
Alaska Sea Grant, msigman@alaska.edu
Paula Cullenberg
Alaska Sea Grant, paula.cullenberg@alaska.edu
Molly McCammon
Alaska Ocean Observing System (AOOS), mccammon@aoos.org
Lillian Alessa
University of Alaska Anchorage, lalessa@alaska.edu
Robin Dublin
Alaska SeaLife Center, robin.dublin@coseealaska.net

An Alaska coastal Community-Based Monitoring (CBM) Workshop was convened in April 2014 in Anchorage, Alaska, in order to identify and respond to common issues for Community-Based Monitoring (CBM) in Alaska and the Arctic. CBM is an approach increasingly used to collect valuable observations and scientific information about environmental change over large geographic areas. For the workshop, CBM was defined broadly to encompass diverse environmental monitoring programs and observing networks that involved collaborations between community members who collect local environmental observations and data and their partners outside the community who support the collection, management, and use of the observations and data. It included all forms of citizen science and the collection and appropriate use of local and traditional knowledge.

The workshop was attended by 130 scientists, engaged community members, and representatives from organizations, universities and agencies from throughout Alaska, six other states, Canada, and Kamchatka. Participants heard from coordinators of programs that provided models for various aspects of CBM and discussed priorities for funders and community members.

The workshop resulted in a productive exchange among CBM practitioners in Alaska and the Arctic. “Lessons learned” and recommendations for best practices in program design, implementation, and evaluation were compiled into a “how to” manual available for download at http://seagrant.uaf.edu/bookstore/pubs/SG-ED-78.html. Links to additional resources are also available on the website developed in conjunction with the workshop: www.alaskacommunitybasedmonitoring.org.

The Uncertainties of Sea Ice: Socio-legal Dynamics in a Changing Arctic Ocean-scape

Kristen Shake
Graduate School of Geography, Clark University, Worcester MA, kshake@clarku.edu
Karen Frey
Graduate School of Geography, Clark University, Worcester MA, kfrey@clarku.edu
Deborah Martin
Graduate School of Geography, Clark University, Worcester MA, demartin@clarku.edu

Sea ice is a dynamic physical element of the greater Arctic marine ecosystem. Changes to the spatial extent of sea ice in the Arctic Ocean simultaneously permits and endangers maritime operations, as well as impacts current debates over maritime boundaries, presenting an interesting challenge for international law. The unique processes of sea ice that make it a vital element of the marine ecosystem are the same properties that make it a problem for the laws that govern polar spaces; sea ice is not a stationary object, it moves through time and space in response to the physical forces of wind, ocean currents, and heating. It is not of the terrestrial or the marine; it is of both, and yet solely of neither. Current legal structures in the greater Arctic region cannot adequately account for the changing physical contexts of sea ice. To date, no internationally agreed upon legal regime for sea ice exists. Over the past few decades, it has been categorized inconsistently within the legal systems of both Canada and the United States as either land, water, or water in an alternative configuration. Climate change in the Arctic has now made it clear that simply categorizing ice as either land or water is no longer adequate. In the Arctic, the interconnectedness between climate change, spatial dimensions of shifting seasonal sea ice extent, and the laws that govern the marine spaces of this region require politic assessment. This project explores the legal and political dimensions of climate induced changes to sea ice extent by asking the following research question: How does dynamic and changing sea ice shape the marine socio-environment, particularly in terms of legal and political contestations in ocean-spaces of the greater Arctic region? This research will contribute to the literature on the greater Arctic Ocean region that has examined different types of political contestations by explicitly examining the role and significance of sea ice in such debates.

Predictable Wind Forced Upwelling Can Lead to a Favorable Feeding Environment for Bowhead Whales in Nearshore Waters near Barrow, Alaska - A Synthesis of Results from BOWFEST

Carin Ashjian
Woods Hole Oceanographic Institution, cashjian@whoi.edu
Craig George
North Slope Borough, craig.george@north-slope.org
Stephen Okkonen
University of Alaska Fairbanks, srokkonen@alaska.edu
Philip Alatalo
Woods Hole Oceanographic Institution, palatalo@whoi.edu
Billy Adams
North Slope Borough, billy.adams@north-slope.org
Harry Brower Jr.
North Slope Borough, harry.brower@north-slope.org
Robert Campbell
University of Rhode Island, rgcampbell@uri.edu
Kim Goetz
National Institute of Water and Atmospheric Research - New Zealand, kim.goetz@niwa.co.nz
Julie Mocklin
NOAA, National Marine Fisheries Service, Julie.Mocklin@noaa.gov
Sue Moore
NOAA, Office of Science & Technology, sue.moore@noaa.gov
David Rugh
NOAA, National Marine Fisheries Service, david.rugh@noaa.gov
Gay Sheffield
University of Alaska Fairbanks, ggsheffield@alaska.edu
Kim Shelden
NOAA, National Marine Fisheries Service, kim.shelden@noaa.gov

Bowhead whales are known to feed on dense patches of euphausiid (krill) and copepod prey near Barrow, Alaska, during late summer/fall, making the whales available nearshore for subsistence hunting. Here we synthesize results from the Bowhead Whale Feeding Ecology Study (BOWFEST, 2007-2011) and earlier studies to demonstrate the importance of wind-forced upwelling to the development of a favorable feeding environment for bowheads near Barrow. Data from ship-based oceanographic surveys and whale prey distributions, aerial and small boat surveys of whale distributions, and stomach contents from whales harvested during the fall hunt at Barrow are related to wind conditions that promoted upwelling and retention of whale krill prey on the Beaufort Shelf northeast of Barrow. Upwelling of water and krill along the shelf was predictably observed under easterly winds; retention of these waters on the shelf following upwelling occurred under low winds or southerly/westerly winds (the “krill trap”). Krill abundances were enhanced on the shelf during these conditions, observed

both from small boats and from aerial surveys. Whale stomach contents varied according to strike location; whales harvested in the shelf waters typically contained krill while those harvested in Barrow Canyon offshore usually contained copepods. Most whales were harvested during wind conditions that were consistent with an active krill trap, suggesting that bowhead whales were feeding on the shelf because their krill prey had been concentrated there. There was considerable inter-annual variability in physical ocean conditions and in the population structure and abundance of krill as well as in the density and distribution of bowheads. Regardless of this variability, whales were able to find at least some krill prey near Barrow in all years of the analysis.

The Arctic Marine Pulses Model: Linking Contiguous Domains in the Pacific Arctic Region

Sue Moore
NOAA, Office of Science & Technology, sue.moore@noaa.gov
Phyllis Stabeno
NOAA, Office of Oceanic & Atmospheric Research Headquarters, phyllis.stabeno@noaa.gov

The Pacific Arctic marine ecosystem extends from the northern Bering Sea, across the Chukchi and into the East Siberian and Beaufort seas. Food webs in this domain are short, a simplicity that belies the biophysical complexity underlying trophic linkages from primary production to humans. Existing biophysical models, such as pelagic-benthic coupling and advective processes, provide frameworks for connecting certain aspects of the marine food web, but do not offer a full accounting of events that occur seasonally across the Pacific Arctic. In the course of the Synthesis of Arctic Research (SOAR) project, a holistic Arctic Marine Pulses (AMP) model was developed that depicts seasonal biophysical 'pulses' across a latitudinal gradient, and linking four previously-described contiguous domains, including the: (i) Pacific-Arctic domain = the focal region; (ii) seasonal ice zone domain; (iii) Pacific marginal domain; and (iv) riverine coastal domain. The AMP model provides a spatial-temporal framework to guide research on dynamic ecosystem processes during this period of rapid biophysical changes in the Pacific Arctic. Some of the processes included in the model, such as pelagic-benthic coupling in the Northern Bering and Chukchi seas, and advection and upwelling along the Beaufort shelf, are already the focus of sampling via the Distributed Biological Observatory (DBO) and other research programs. Other aspects such as biological processes associated with the seasonal ice zone and trophic responses to riverine outflow have received less attention. The AMP model could be enhanced by the application of visualization tools to provide a means to watch a season unfold in space and time. The capability to track sea ice dynamics and water masses and to move nutrients, prey and upper-trophic predators in space and time would provide a strong foundation for the development of predictive human-inclusive ecosystem models for the Pacific Arctic.

Interannual Variability and Change in an Arctic Ecosystem: Can We Separate a Signal from the Noise?

Robert Day
ABR, Inc., bday@abrinc.com
Arny Blanchard
University of Alaska Fairbanks, alblanchard@alaska.edu
Adrian Gall
ABR, Inc., agall@abrinc.com
Russell Hopcroft
University of Alaska Fairbanks, rrhopcroft@alaska.edu
Thomas Weingartner
University of Alaska Fairbanks, tjweingartner@alaska.edu
Lisanne Aerts
LAMA Ecological, lisanne@lamaecological.com
Julien Delarue
JASCO Applied Sciences, Julien.Delarue@jasco.com
Elizabeth Dobbins
University of Alaska Fairbanks, eldobbins@alaska.edu
Jennifer Questel
University of Alaska Fairbanks, jmquestel@alaska.edu
Sheyna Wisdom
Fairweather Science, sheyna.wisdom@fairweather.com
Caryn Rea
ConocoPhillips Alaska Inc., caryn.rea@conocophillips.com
Michael Macrander
Shell Exploration & Production Company, a.macrander@shell.com
Steinar Eldoy
Statoil USA E&P, Inc., steine@statoil.com

Assessing change in ecosystems against a background of climate change requires understanding sources and scales of variability. We conducted the multidisciplinary ecosystem study CSESP in the northeastern Chukchi Sea annually and seasonally during 2008–2013. The offshore northeastern Chukchi has two main ecosystems that extend over most of Hanna Shoal, with the more pelagic system associated primarily with warm Bering Sea Water and occurring in the Central Channel and western Hanna Shoal; in contrast, the more benthic system is associated primarily with the presence of cold Winter Water on the bottom and lies southeast of Hanna Shoal. These two systems' components are affected by variability at three scales (spatial, interannual, and seasonal): the pelagic system is driven primarily by variation in temporal factors (interannual/seasonal effects), whereas the benthic system is driven primarily by variation in spatial factors (e.g., environmental heterogeneity, water-circulation). Because temporal variation of the pelagic system is so high, it will be difficult to detect change in most components unless the effect size is great. However, detecting benthic

change is not necessarily easier because only half of the variation in benthic data can be explained by temporal and spatial effects. A study design aimed at detecting ecosystem change while integrating multiple disciplines should focus on component(s) with high variability and address types and scales of variability. Repeated-measures study designs are useful for detecting change in the face of such variability; however, a study design oriented toward monitoring benthic change will not necessarily be adequate for detecting pelagic change. Accounting for seasonal variation also is important in this seasonal arctic system.

A Northeastern Chukchi Shelf Ecosystem Observatory: Year 1 Results and Year 2 Build-out

Claudine Hauri
University of Alaska Fairbanks, chauri@alaska.edu
Russell Hopcroft
University of Alaska Fairbanks, rrhopcroft@alaska.edu
Catherine Lalande
Universite Laval, Catherine.Lalande@takuvik.ulaval.ca
Andrew McDonnell
University of Alaska Fairbanks, amcdonnell@alaska.edu
Kate Stafford
University of Washington, stafford@apl.washington.edu
Peter Winsor
University of Alaska Fairbanks, pwinsor@alaska.edu
Seth Danielson
University of Alaska Fairbanks, sldanielson@alaska.edu

Advances in instrument technology now allow us to autonomously sample the marine ecosystem from the vantage of multiple disciplines and across multiple trophic levels. We describe a coordinated set of subsurface moorings on the northeastern Chukchi Sea shelf that record with high temporal resolution throughout the year, including the under-sampled and poorly understood seasons when sea ice inhibits ship-based sampling. The fully outfitted observatory simultaneously records ocean and sea ice physics, nutrient and carbonate chemistry, suspended and sinking particulate matter, phytoplankton, zooplankton, fisheries, and marine mammal data sets, thereby providing an unprecedented view into the mechanistic workings of the Chukchi shelf ecosystem. The observatory site - on the southeastern flank of Hanna Shoal and northwest of the head of Barrow Canyon - is well situated to monitor the shelf's nutrient and carbon cycles and how changing wind, wave, and ice affect the regional oceanography. The data will provide researchers and resource managers with a broad-spectrum and multi-year set of reference observations that can be applied to evaluating and improving regional and global-scale biogeochemical, ice-ocean circulation and ecosystem models.

A single mooring was deployed in September 2014 and recovered in August 2015, comprising the first year of the observatory in the water. The parameters recorded included: currents, temperature, salinity, pressure, significant wave height and direction, ice thickness and keel depth, chlorophyll *a* fluorescence, beam transmission, photosynthetically available radiation, acoustic backscatter at 38/125/200/455 KHz, and particle size spectra and concentrations. The 2015 deployment consisted of three co-located moorings carrying an expanded set of instrumentation including a dissolved oxygen sensor, a nitrate sensor, a colored dissolved organic matter sensor, a sediment trap, a passive acoustic recorder, and water column photography. We provide an

overview of the mooring observatory objectives, design, and show highlights from the first year's worth of data returns.

Plenary Sessions - Wednesday, January 27

Plenary Sessions: Wednesday, January 27 -- Bering Sea and Aleutian Islands

TIME	TITLE	PRESENTER	SECTION
8:00 - 8:15 AM	The Status of the Southern Bering Sea in 2015: Warm	Phyllis Stabeno	Climate and Oceanography
8:15 - 8:30 AM	Spatial Prediction of Changes in Flood Susceptibility and Vegetation Distribution Due to Sea-level Rise on the Yukon-Kuskokwim Delta	Jon S. Allen *	Climate and Oceanography
8:30 - 8:45 AM	Surface Mapping of the Bering Sea During Seasonal Ice Retreat	Jessica Cross	Climate and Oceanography
8:45 - 9:00 AM	A 4D variational reanalysis of the Bering Sea circulation in 2007-2010	Gleb Panteleev	Climate and Oceanography
9:00 - 9:15 AM	Coastal Community Ocean Observers (C2O2): A Network of Community-driven Coastal Ocean Observations	Peter Winsor	Climate and Oceanography
9:15 - 9:30 AM	A High-Resolution Coupled Tide and Storm Surge Model for the Gulf of Alaska, Bering Sea, Chuckchi Sea, and Beaufort Sea	Brian Joyce *	Climate and Oceanography
9:30 - 10:00 AM	**BREAK**		
10:00 - 10:15 AM	Using Species Distribution Models to Define Essential Fish Habitat in Alaska	Ned Laman	Fishes and Fish Habitats
10:15 - 10:30 AM	Seasonal Phenology of Zooplankton Composition in the Southeastern Bering Sea, 2008-2010	Lisa Eisner	Lower Trophic Levels
10:30 - 10:45 AM	Coherence in Population Dynamics of Western Alaska Chinook Salmon and Relationships to Environmental Forcing Over Their Life-cycle	Daniel E. Schindler	Fishes and Fish Habitats
10:45 - 11:00 AM	Early Marine Ecology of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) on the Yukon Delta, Alaska	Katharine Miller	Fishes and Fish Habitats
11:00 - 11:15 AM	Bioeffects Assessment in Kvichak and Nushagak Bay, Alaska: Characterization of Soft Bottom Benthic Habitats, Fish Body	Ian Hartwell	Fishes and Fish Habitats
11:15 - 11:30 AM	Evaluating the Freshwater and Marine Drivers of Yukon River Chinook Survival with Stage-structured Life Cycle Models	Curry Cunningham	Fishes and Fish Habitats
11:30 - 1:00 PM	**LUNCH - BREAK ON YOUR OWN**		

* Masters; ** Doctorate

Plenary Sessions: Wednesday, January 27 -- Bering Sea and Aleutian Islands

TIME	TITLE	PRESENTER	SECTION
1:00 - 1:15 PM	Tracking the Foraging Movements of Short-tailed Shearwaters During the Non-breeding Period, Using Geo-location Sensors	Natalie Bool *	Seabirds
1:15 - 1:30 PM	Groundwork for Examining Seabird Responses to Bering Sea Regime Shifts.	Alexis Will *	Seabirds
1:30 - 1:45 PM	Application of a Scalable Change Detection Tool to Assess Climate Change Vulnerability for Important Bird Areas in the Bering Sea and Aleutian Islands	Melanie Smith	Seabirds
1:45 - 2:00 PM	Mixing it Up in Alaska: Habitat Use of Adult Female Steller Sea Lions (*Eumetopias jubatus*) Reveals a Variety of Foraging Strategies	Michelle Lander	Marine Mammals
2:00 - 2:15 PM	Assessment of a Genetics Based Capture-Mark-Recapture Approach for Estimation of Abundance and Demographic Rates of Pacific Walruses	Patrick Lemons	Marine Mammals
2:15 - 2:30 PM	Integration of Oceanographic Data with Fin Whale Calling Presence in the Bering Sea	Srishti Dasarathy *	Marine Mammals
2:30 - 3:00 PM	BREAK		
3:00 - 3:15 PM	Using Vocal Dialects to Assess the Population Structure of Bigg's Killer Whales in Alaska	Deborah Sharpe *	Marine Mammals
3:15 - 3:30PM	Thinking Strategically in the Aleutian Archipelago	Douglas Burn	Human Dimensions
3:30 - 3:45 PM	Testing Sociocultural Impacts of Declining Chinook Salmon Runs on Yukon River Communities	Hillary Hafner	Human Dimensions
3:45 - 4:00 PM	Broken Links: How Limited Entry, Markets, and Family Have Transformed Access to and Participation in Bristol Bay's Commercial Fisheries	Jesse Coleman *	Human Dimensions
4:00 - 4:15 PM	Carbon Sources of Ice Seals During Recent Environmental Shifts in the Bering Sea	Shiway Wang	Human Dimensions
4:15 - 4:30 PM	Jellyfish - Fish Trophic Interactions in the Bering Sea: Ecosystem Impacts of Jellyfish Population Fluctuations	Jim Ruzicka	Ecosystem Perspectives
4:30 - 4:45 PM	Early Warning Indicators to Track Resilience in the Bering Sea Ecosystem	Mike Litzow	Ecosystem Perspectives

* Masters; ** Doctorate

Plenary Session Abstracts

Wednesday, January 27

The Status of the Southern Bering Sea in 2015: Warm

Phyllis Stabeno
NOAA, Pacific Marine Environmental Laboratory, phyllis.stabeno@noaa.gov
Janet Duffy-Anderson
NOAA, Alaska Fisheries Science Center, janet.duffy-anderson@noaa.gov
Ed Farley
NOAA, Alaska Fisheries Science Center, ed.farley@noaa.gov
Ron Heintz
NOAA, Alaska Fisheries Science Center, ron.heintz@noaa.gov

In 2014, after ~6 years of extensive spring ice and cold summer conditions, the Bering shelf experienced a warm year. For the first time since 2005, sea ice did not reach the mooring site M2 (56.9°N, 164.1°W). Temperatures over the southern shelf were comparable to the very warm conditions observed in 2005, with depth-averaged temperatures at M2 of ~8°C in late summer. The following winter (2015) ice once again did not reach M2 and warm water associated with the North Pacific "blob" entered the southern Bering Sea through Unimak Pass. The combination of warm ocean conditions in the Bering Sea in 2014, warm water entering the Bering Sea and the lack of ice resulted in temperatures in the winter and early spring of 2015 being the warmest measured at M2 since its first deployment 21 years ago in 1995. Warm conditions continued through summer of 2015. One of the primary hypotheses from the Bering Sea Integrated Ecosystem Research Study (2007 – 2010) was that consecutive warm years would reduce the abundance of large, lipid-rich crustacean zooplankton, adversely affecting age-0 walleye pollock provisioning for overwinter survival and influencing recruitment success. A special survey executed in September 2015 to evaluate the consecutive warm year hypothesis and examine ecosystem change was undertaken. Although some warm year patterns were observed, we noted that ecosystem change was not occurring as rapidly as predicted by the consecutive year hypothesis. Though abundances of walleye pollock juveniles were low, it was noted that age-0 pollock were consuming large numbers of large *Calanus* spp. copepods, an observation more typical of cold year conditions. On-board rapid analyses of the zooplankton prey field indicated large, lipid rich copepods were present in the water column, especially in the north. Collectively, our data indicate a slower ecosystem response to oceanographic forcing than originally predicted; suggesting multi-year stanzas of climate conditions are required for a full ecosystem regime shift.

Spatial Prediction of Changes in Flood Susceptibility and Vegetation Distribution Due to Sea-level Rise on the Yukon-Kuskokwim Delta

Jon S. Allen
University of Alaska Anchorage, jsallen@uaa.alaska.edu
Thomas Ravens
University of Alaska Anchorage, tmravens@uaa.alaska.edu

The low-lying plains of the Yukon-Kuskokwim Delta, one of the largest in the world, is home to rich sea-bird nesting grounds and several remote, predominantly Alaska Native communities. The delta is frequently subjected to storm surge events, resulting in widespread flooding that penetrates more than 10 km inland. The frequency and severity of these large storm surge events are increasing, endangering nearshore communities and nesting habitat.

Using a validated storm-surge model to simulate the largest Bering Sea storms over the past twenty years, the University of Alaska Anchorage has developed the spatially variant annual inundation index (AII) to characterize flood susceptibility. This index is based on the integration of water depth over each time step of a modeled storm and is weighted by the estimated return period of the storm as determined by Gumbel extreme value analysis. Simulations and AII calculations are repeated under three sea-level-rise scenarios -- 40 cm, 80 cm and 120 cm -- in accordance with the latest IPCC report. An apparent spatial correlation between AII and vegetation type determined at current climatic conditions allows the prediction of changes in vegetation type and distribution under each sea-level-rise scenario. These changes influence wildlife patterns and nesting suitability and thus subsistence land use by local populations. The revised vegetation and flood vulnerability maps aid natural resource managers and civil planners anticipate future conditions and plan accordingly.

Surface Mapping of the Bering Sea During Seasonal Ice Retreat

Jessica Cross
Cooperative Institute for Alaska Research, Jessica.Cross@noaa.gov
Calvin Mordy
Joint Institute for the Study of Atmosphere and Ocean, Calvin.W.Mordy@noaa.gov
Christian Meinig
NOAA, Pacific Marine Environmental Laboratory, Christian.Meinig@noaa.gov
Edward Cokelet
NOAA, Pacific Marine Environmental Laboratory, Edward.D.Cokelet@noaa.gov
Phyllis Stabeno
NOAA, Pacific Marine Environmental Laboratory, Phyllis.Stabeno@noaa.gov
Heather Tabisola
Joint Institute for the Study of Atmosphere and Ocean, Heather.Tabisola@noaa.gov
Wiley Evans
University of Alaska Fairbanks, Wiley.Evans@noaa.gov

The U.S. Arctic and sub-Arctic regions are rapidly changing, creating potentially large impacts to marine ecosystems and ecosystem services. However, much of the current observing technology is ill suited to fully quantify these important changes. The harsh, remote environment, the expansive area, the extremely fine scale features and the dynamic ecosystem all present clear technical and financial challenges for ocean observations, especially using traditional observational methods and platforms. During the summer of 2015, NOAA's new Innovative Technology for Arctic Exploration (ITAE) Program successfully completed a large-scale research mission in the Bering Sea using two Saildrones, a novel unmanned autonomous surface vehicle. The exceptional speed, endurance, and maneuverability of the Saildrone enabled the identification, exploration and mapping of important fine-scale features. The evolution of sea-ice melt was tracked throughout the mission. We observed a clear signature of recent ice-melt in the vicinity of St. Matthew Island. As the deployment progressed, mixing and solar heating moderated these signals. Additionally, we were able to observe the impacts of the Yukon River in very shallow waters in Norton Sound. We found evidence of a frontal feature that isolated the river-influenced Sound waters from the rest of the shelf. During subsequent deployments, the ITAE Program plans incorporate ecosystem assessment tools that could enhance monitoring capacities and aid management of the region's multi-billion dollar annual commercial and its subsistence fishing industries.

A 4D Variational Reanalysis of the Bering Sea Circulation in 2007-2010

Gleb Panteleev
University of Alaska Fairbanks, gleb@iarc.uaf.edu
Max Yaremchuk
Naval Research Laboratory, max.yaremchuk@nrlssc.navy.mil
Oceana Francis
University of Hawaii, oceanaf@hawaii.edu
Phyllis Stabeno
NOAA, Alaska Region, phyllis.stabeno@noaa.gov
Tom Weingartner
University of Alaska Fairbanks, weingart@ims.uaf.edu
Jinlun Zhang
University of Washington, zhang@apl.washington.edu

A two-way nested 4d-variational data assimilation system is implemented in the Eastern Bering Sea (EBS) to investigate changes in circulation and thermodynamic state for a 3.8-year period. Assimilated observations include data from 19 moorings deployed on the shelf and in the Bering Strait, 1705 hydrographic stations occupied during eight surveys, and remotely sensed sea surface temperature and sea surface height (SSH) data. Validation of the presented 4dVar reanalysis against the output of two sequential data-assimilative systems (the Bering Ecosystem Study ice-ocean Modeling and Assimilation System (BESTMAS) and the Arctic Cap Nowcast-Forecast System (ACNFS)) has shown that the product is more consistent with the observed transports in the Bering Strait and in the EBS interior both in terms of their magnitude and time variability. Analysis of the data-optimized solution quantifies a sequence of wind-forced events that resulted in the anomalous heat and freshwater transports through the Bering Strait, including a 28-day long flow reversal that occurred in November of 2009 and carried Siberian Coastal Current water as far as the Gulf of Anadyr. Lagrangian study of the Arctic-bound Pacific waters indicates the extreme importance of the cross-shelf exchange along the path of the Bering Slope Current and quantifies the spectrum of residence times for the waters entering EBS through Unimak Pass and through Aleutian passages. Residence times in the EBS cold pool are diagnosed to be 2-3 times longer than those in the surrounding waters.

Coastal Community Ocean Observers (C2O2): A Network of Community-driven Coastal Ocean Observations

Peter Winsor
University of Alaska Fairbanks, pwinsor@alaska.edu
Seth Danielson
University of Alaska Fairbanks, sldanielson@alaska.edu
Courtney Carothers
University of Alaska Fairbanks, clcarothers@alaska.edu
Glen Clough
Old Harbor, gclough65@hotmail.com
Lee Kayotuk
City of Kaktovik, Leekayotuk@msn.com
Pamela Lestenkof
Ecosystem Conservation Office, St Paul Island, pmlestenkof@aleut.com

The Coastal Community Ocean Observers (C2O2) is a participatory science program that seeks to build a framework for long-term community-driven monitoring of oceanic environmental variables. Our program combines a cost-efficient means for communities to collect environmental data with local interest, promoting mutually beneficial partnerships and relationships for collecting and sharing information.

The C2O2 program has now been initialized in three communities, Kaktovik, Old Harbor, and St. Paul – communities that have uniquely different climates, cultures, and local concerns. Using GPS-enabled conductivity-depth-salinity recorders, all three communities have all generated hydrographic data which is reported in near-real time via a web interface and immediately available on the project website for community residents, scientists and stakeholders.

Here we describe our experiences with starting up the C2O2 program, together with some initial results and outline a build-out plan for the future, including interfacing with similar efforts in Canada to create a linked network of ocean observations in a south-to-north frame work to detect and describe climate change propagation and its impact on local ecosystems and communities.

A High-Resolution Coupled Tide and Storm Surge Model for the Gulf of Alaska, Bering Sea, Chukchi Sea, and Beaufort Sea

Brian Joyce
University of Notre Dame, bjoyce@nd.edu
Joannes Westerink
University of Notre Dame, jjw@nd.edu
Jesse Feyen
NOAA, National Ocean Service, jesse.feyen@noaa.gov
Robert Grumbine
NCEP/EMC/Marine Modeling and Analysis Branch, robert.grumbine@noaa.gov
Andre van der Westhuysen
NCEP/EMC/Marine Modeling and Analysis Branch, andre.vanderwesthuysen@noaa.gov

The western coastline of Alaska spans over a diverse topography ranging from low lying tundra to sharp volcanic relief. Included in this range are areas highly susceptible to powerful storms which cause coastal flooding, erosion and have many other negative effects on the environment and commercial efforts in the region. To better understand the multi-scale and interactive physics of the deep ocean, continental shelf, near shore, and coast, a large unstructured domain hydrodynamic model is being developed using the finite element, free surface circulation code ADCIRC. This is a high resolution, accurate, and robust computational model of Alaska's coastal environment capable of simulating tides, storm surges and the effect of wind waves. ADCIRC has been extensively used in the Gulf of Mexico, east coast of the U.S., the Great Lakes and many other regions worldwide. These models are applied by FEMA, the U.S. Army Corps of Engineers, the USNRC and NOAA.

ADCIRC's capability to use high resolution unstructured grids is vital to accurately modeling tides and storm surge in Alaska. The geographic and topographical complexity of the Alaskan coastline can only be captured with very high model resolution. Hydrodynamically, the tides in in this region are very complex with a large number of amphidromic points and a very large tidal range. Correctly modeling this tidal response locally requires a large scale, yet spatially well resolved tidal model. Using historical meteorological fields, the model is capable of simulating storm events and the resulting surge. With a high resolution grid, this storm surge can be modeled in vulnerable coastal areas and estuarine and deltaic systems. It also allows for the model to capture where there may be strong localized amplification of storm surge. Accurate knowledge of tidal and storm surge response in water elevation and currents is vital to providing preventative measures against the coastal erosion and flooding problems occurring along the Alaskan coast. Both the tidal and surge model have numerous observed data points collected by NOAA for validation. In this talk we will present on the development of the model as well as results from the tidal and storm simulations.

Using Species Distribution Models to Define Essential Fish Habitat in Alaska

Chris Rooper
NOAA, Alaska Fisheries Science Center, Chris.Rooper@noaa.gov
Ned Laman
NOAA, Alaska Fisheries Science Center, Ned.Laman@noaa.gov
Kali Turner
NOAA, Alaska Fisheries Science Center, Kali.Turner@noaa.gov
Dan Cooper
NOAA, Alaska Fisheries Science Center, Dan.Cooper@noaa.gov

Defining essential habitats for fishes is important for managing groundfish in Alaska. Species distribution models have been widely used in conservation biology and terrestrial systems to define the potential habitat for organisms of interest. The models themselves can take a number of forms, from relatively simple frameworks such as generalized linear or additive models to complex modeling frameworks such as boosted regression trees, maximum entropy models, two-stage models or other formulations. We used a variety of modeling methods and data sets from scientific surveys and commercial fisheries to define the habitats for over 30 fish species in three regions of Alaska. Adult, juvenile, larval and egg stages were modeled in four seasons where data were available. Depth was the dominant variable determining the distribution of most adult and juvenile life history stages. Sea surface temperature was the most important variable for egg and larval stages. Using the models, maps were developed that identified local hot spots for each species and life stage. These maps will be used for marine spatial planning and assessing impacts of anthropogenic activities in Alaska's marine environment.

Seasonal Phenology of Zooplankton Composition in the Southeastern Bering Sea, 2008-2010

Lisa Eisner
NOAA, Alaska Fisheries Science Center, lisa.eisner@noaa.gov
Alexei Pinchuk
University of Alaska Fairbanks, aipinchuk@alaska.edu
Colleen Harpold
NOAA, Alaska Fisheries Science Center, colleen.harpold@noaa.gov
Janet Duffy-Anderson
NOAA, Alaska Fisheries Science Center, janet.duffy-anderson@noaa.gov
Elizabeth Siddon
NOAA, Alaska Fisheries Science Center, elizabeth.siddon@noaa.gov

The availability of large crustacean zooplankton prey is critical to the condition and survival of forage fish (e.g., age-0 walleye pollock), sea birds, and marine mammals in the eastern Bering Sea. Zooplankton community composition and abundances of large lipid-rich copepods (e.g., *Calanus* spp.) have been evaluated for single seasons, but few studies have investigated seasonal variations in this region. Here, we investigate seasonal changes in taxa (community structure), stage composition (where appropriate), and diversity from spring through late summer/early fall over three consecutive years. Zooplankton taxonomic samples were collected with oblique bongo tows over the water column during spring (April-May), mid-summer (June-July) and late summer/early fall (August-September) across the southeastern Bering Sea shelf in 2008-2010. Zooplankton abundances were evaluated by oceanographic region, season and year, and related to water mass characteristics (temperature and salinity) and other environmental drivers. Finally, zooplankton phenology were compared to changes in forage fish composition to determine potential overlap of fish predators and zooplankton prey.

Coherence in Population Dynamics of Western Alaska Chinook Salmon and Relationships to Environmental Forcing Over Their Life-cycle

Jan Ohlberger
School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195; janohl@uw.edu
Mark D. Scheuerell
NOAA, Northwest Fisheries Science Center; mark.scheuerell@noaa.gov
Daniel E. Schindler
School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195; deschind@uw.edu

A central problem in understanding how species respond to global change is in parsing the effects of local drivers of population dynamics from regional and global drivers that are shared among populations. Management and conservation efforts that typically focus on a particular population would benefit greatly from being able to separate the effects of environmental processes at local, regional and global scales. One way of addressing this challenge is to integrate data across multiple populations and use multivariate time series approaches to estimate shared and independent components of dynamics among neighboring populations. Here, we use a dataset of 15 populations of Chinook salmon covering a broad geographical range in the eastern North Pacific Ocean to show how Dynamic Factor Analysis (DFA) can be used to estimate temporal coherence in population dynamics and to detect environmental drivers across spatial scales. Our results show that productivity dynamics of Chinook salmon populations strongly co-vary at the regional scale, but to a lesser degree at larger spatial scales. The timing of river ice break-up in spring was identified as an important driver of regional productivity dynamics. In addition, broad-scale variability in population productivity was linked to the North Pacific Gyre Oscillation (NPGO), a dominant pattern of sea surface height variability. These broad-scale patterns in productivity dynamics may be associated with recent regime shifts in the Northeast Pacific Ocean. However, our results also demonstrate that populations within regions do not always respond consistently to the same environmental drivers, thus suggesting location-specific impacts.

Early Marine Ecology of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) on the Yukon Delta, Alaska

Katharine Miller
NOAA, Alaska Fisheries Science Center, katharine.miller@noaa.gov
Kathrine Howard
Alaska Department of Fish & Game, kathrine.howard@alaska.gov
Jim Murphy
NOAA, Alaska Fisheries Science Center, jim.murphy@noaa.gov

Chinook salmon are an important commercial, recreational, and subsistence resource in the Yukon River. From mid-2000 to the present, the Arctic-Yukon-Kuskokwim region has experienced substantial declines in Chinook salmon production resulting in the declaration of a fishery disaster for the region. The causes of the population declines and fluctuations are not fully known; however, the early marine period, when the fish are transitioning from fresh to salt water, is recognized as critical stage during which predation and growth strongly affect winter marine survival and future recruitment. In 2014, we initiated a study to characterize habitat use, size, diet, marine entry timing, and condition of juvenile Chinook salmon in the Yukon River Delta to improve our understanding of their early marine ecology. With the assistance of Emmonak fishermen and technicians, bi-weekly sampling on each of the three main lower Yukon tributaries occurred from ice break-up through the end of July in 2014 and 2015. We also sampled five transects on the Yukon Delta front in June, July and August of each year. This research provides new information on spatial and temporal migratory patterns of juvenile Yukon River Chinook salmon. Habitat utilization patterns, diet, and energy density of juvenile Chinook salmon provide insight into how Chinook salmon interact with the complex and diverse habitats of the Yukon River Delta and Delta front during their transition from freshwater to marine habitats. This research expands on the only prior study of juvenile salmon from the Yukon River which was conducted in 1986.

Evaluating the Freshwater and Marine Drivers of Yukon River Chinook Survival with Stage-structured Life Cycle Models

Curry Cunningham
University of Alaska Fairbanks, cunninghamcurry@uw.edu
Peter Westley
University of Alaska Fairbanks, pwestley@alaska.edu
Milo Adkison
University of Alaska Fairbanks, mdadkison@alaska.edu

Recent declines in the abundance and productivity of Chinook (*Oncorhynchus tshawytscha*) populations of the Yukon River watershed has led to increased interest in understanding the environmental drivers of variation in survival throughout the entire life cycle. To better understand the population dynamics of Chinook within this region, we have created a hypothesis-testing framework for assessing the influence of climatic, hydrologic, and biotic factors on the survival of Chinook during both freshwater and marine portions of the life cycle. This framework is a Bayesian age and stage-structured population dynamics model that estimates the influence of environmental covariates on survival through specific life stages when fit to available abundance indices. Population-specific survival rates are modeled as a series of stage-specific Beverton-Holt functions, in which the productivity and capacity parameters are time varying and described as functions of environmental covariates. Information theoretic and Bayesian model selection methods are employed to confront model structural uncertainty and define the set of environmental covariates that have the greatest potential to explain observed trends in survival over time. Preliminary results from an application of this model to the Chena and Salcha River populations will be presented.

Tracking the Foraging Movements of Short-tailed Shearwaters During the Non-breeding Period, Using Geo-location Sensors

Natalie Bool
UTAS, natalie.bool@utas.edu.au
Mark Hindell
UTAS, mark.hindell@utas.edu.au

During the non-breeding season seabirds are not restrained by chick rearing duties, consequently they are free to range over great distances to search for prey. The short-tailed shearwater (*Ardenna tenuirostris*, STSH) is an abundant and highly mobile seabird that breeds in Australia but spends the non-breeding period in the waters surrounding Alaska. They are a top consumer of marine resources and play an important role in the functioning of marine food webs where they forage. Prior to the miniaturization of geo-location devices knowledge of STSH foraging distribution during the non-breeding season was restricted to at-sea surveys and data on the movements of individual birds throughout the non-breeding period was unavailable. To identify individual bird foraging movements, to assess habitat use and spatial overlap between individuals during the non-breeding season we attached light-based geo-location sensors to STSHs prior to their departure from the Southern Hemisphere at Wedge Island, Tasmania, Australia (2012 – 2015). Data collected from the loggers revealed that upon reaching the non-breeding areas in the Northern Hemisphere the study birds spent on average half of the non-breeding period in one of several regions including the Sea of Japan, the North Pacific Ocean, the central Bering Sea and the western extent of the Gulf of Alaska. Before returning to the southern breeding areas birds travelled in a clockwise direction to additional foraging areas including the Chukchi Sea. Restricted flight range due to feather molt and or dense aggregations of prey availability in the chosen foraging areas may account for the site fidelity observed during the early stage of the non-breeding period. These results provide a baseline to improve understanding of the mechanisms driving STSH foraging distribution during the non-breeding season.

Groundwork for Examining Seabird Responses to Bering Sea Regime Shifts

Alexis Will
University of Alaska Fairbanks, awill4@alaska.edu
Ruokun Zhou
University of Calgary, ruokun.zhou@ucalgary.ca
Evgenia Kitaiskaia
University of Alaska Fairbanks, ekitaiskaia@alaska.edu
Scott Hatch
Institute for Seabird Research and Conservation, shatch.isrc@gmail.com
Martha Hatch
Institute for Seabird Research and Conservation, shatch.isrc@gmail.com
Katherine Wynne-Edwards
University of Calgary, kewynnee@ucalgary.ca
Alexander Kitaysky
University of Alaska Fairbanks, askitaysky@alaska.edu

Physiological data from the last two decades indicate that piscivorous (fish-eating) seabirds breeding on the Pribilof Islands are incurring less food stress during warm (high Pacific Decadal Oscillation index, PDO) compared to cold (low PDO) years. PDO patterns suggest that from the mid-1940s- to mid-1970s oceanographic conditions in the region were generally cold, yet the preceding decades were relatively warm. Thus during the last century the Bering Sea ecosystem has experienced several major regime shifts, however, our knowledge as to how seabirds responded to those changes is limited. Currently we are in the midst of an on-going investigation of how piscivorous seabirds responded physiologically and behaviorally to these past regime shifts by analyzing feathers of museum specimens. Prior to working with irreplaceable historic samples we validated our methodological approaches in two ways. 1) We present evidence that glucocorticoids, (CORT) indicative of nutritional stress, are present and measurable in the feathers of our focal species (thick-billed and common murres, and black- and red-legged kittiwakes). 2) Murres lose and replace their flight feathers all at once during their post-reproductive molt, which pinpoints the timing of their exposure to stress. Kittiwakes, however, undergo a continuous flight feather molt, the onset of which may vary depending on food availability during reproduction. In order to clearly interpret CORT concentrations and dietary signatures (based on stable isotope analysis) found in kittiwake feathers we conducted an experimental validation study on Middleton Island. We show how the patterns of stress and stable isotope signatures of individuals reflected a change in foraging conditions between two years, one in which they received supplemental food, and one in which they did not. Our findings provide the foundational knowledge necessary to proceed with an evaluation of the physiological and foraging responses of seabirds to historic regime shifts in the Bering Sea.

Application of a Scalable Change Detection Tool to Assess Climate Change Vulnerability for Important Bird Areas in the Bering Sea and Aleutian Islands

Melanie Smith
Audubon Alaska, masmith@audubon.org
William Koeppen
Axiom Consulting & Design, will@axiomalaska.com
Aaron Poe
Aleutian and Bering Sea Islands Landscape Conservation Cooperative, aaron_poe@fws.gov
Katherine Kuletz
U.S. Fish and Wildlfie Service, kathy_kuletz@fws.gov
Heather Renner
U.S. Fish and Wildlfie Service, heather_renner@fws.gov
Benjamin Sullender
Audubon Alaska, bsullender@audubon.org
Thomas Van Pelt
Transboundary Ecologic, tom@xboundary.org
Jeremy Littell
U.S. Geological Survey, Alaska Science Center, jlittell@usgs.gov
Ellen Tyler
Ellen Tyler Consulting, ellenparrytyler@gmail.com
Joel Reynolds
Western Alaska Landscape Conservation Cooperative, joel_reynolds@fws.gov

Climate change is already affecting the Bering Sea and Aleutian Islands region in Alaska. Newly available downscaled marine climate models for this region offer the opportunity to assess projected changes in habitats important to marine birds. We developed an open-access tool to conduct batched, change detection analyses of large raster datasets representing a suite of physical climate variables and climate-derived biological variables for the marine habitat in the region. We compared projected conditions from a 30 year past time period with those from a 30 year future time period using three coupled, ocean-climate models. We focused these analyses on pelagic polygons that have been defined as globally significant Important Bird Areas. We developed indices of change for selected marine habitat variables to identify which areas might experience the greatest amount of total change in a future climate regime. We will share details of the methods for analyzing change and prioritizing areas with the greatest change. We will also discuss the potential for scalable future applications that could evaluate large scale projected changes in other essential habitat for marine species. Our results will increase managers' understanding about which areas are projected to experience the greatest climate-related changes in key habitat parameters (e.g. prey availability), and consequently which marine bird populations may be most vulnerable to climate change.

This knowledge can also help researchers prioritize future efforts to better understand the ecological effects of climate on seabirds in the Bering Sea and Aleutian Islands.

Mixing It Up in Alaska: Habitat Use of Adult Female Steller Sea Lions (*Eumetopias jubatus*) Reveals a Variety of Foraging Strategies

Michelle Lander
NOAA, Alaska Fisheries Science Center, michelle.lander@noaa.gov
Brian Fadely
NOAA, Alaska Fisheries Science Center, brian.fadely@noaa.gov
Thomas Gelatt
NOAA, Alaska Fisheries Science Center, tom.gelatt@noaa.gov
Jeremy Sterling
NOAA, Alaska Fisheries Science Center, jeremy.sterling@noaa.gov
Devin Johnson
NOAA, Alaska Fisheries Science Center, devin.johnson@noaa.gov
Martin Haulena
Vancouver Aquarium, martin.haulena@vanaqua.org
Susanne McDermott
NOAA, Alaska Fisheries Science Center, susanne.mcdermott@noaa.gov
Lorrie Rea
University of Alaska Fairbanks, ldrea@alaska.edu
Kimberlee Beckmen
Alaska Department of Fish & Game, kimberlee.beckmen@alaska.gov
Michael Rehberg
Alaska Department of Fish & Game, michael.rehberg@alaska.gov
Noel Adolfson Pelland
NOAA, Alaska Fisheries Science Center, Noel.Pelland@noaa.gov

There is limited information regarding the habitat use of adult female Steller sea lions (SSL; *Eumetopias jubatus*) due to logistics associated with capture and handling techniques. Given the paucity of telemetry data for this age class in western Alaska, which is still experiencing population declines, we deployed satellite transmitters on nine adult female SSL from the western and central Aleutian Islands (AI) from 2011-2014. This effort followed a pilot study during which three adult female SSL were successfully immobilized and tagged in Southeast Alaska (SEAK) during 2010 to assess the efficacy of a novel darting protocol. To identify habitat features of biological importance to adult female SSL in Alaska, location data were processed with a continuous-time correlated random walk model and kernel density estimates (KDE) of predicted locations were used to compute individual-based utilization distributions. Diving behaviors (mean, maximum, and frequency of dive depths) and KDEs were examined relative to a series of static and dynamic environmental variables using linear mixed-effects models. Habitat use varied within and among individuals, but all response variables were significantly related to a combination of the predictor variables season, distance to nearest SSL site, bathymetric slope, on/off shelf, sea surface temperature, sea surface height, proportion of daylight, and some interaction effects ($P \leq 0.05$).

Habitat use of SSL from SEAK was consistent with previous reports and reflected the seasonal distribution of predictable forage fish, whereas SSL from the AI used a variety of marine ecosystems and habitat use was more variable, providing new insights into the foraging ecology of adult females from those areas. For example, six animals remained on the Aleutian/Western Bering Sea Shelf, whereas three animals conducted large looping trips (1-8 days) beyond the continental shelf, and in some cases the Aleutian Trench, into pelagic waters of the western subarctic domain in the North Pacific. One animal specifically targeted productive waters entrained by a large, persistent eddy. These results have improved our understanding of the habitat features necessary for the conservation of adult female SSL and have been useful for reviewing designated critical habitat for Steller sea lions throughout the U.S. range.

Assessment of a Genetics Based Capture-Mark-Recapture Approach for Estimation of Abundance and Demographic Rates of Pacific Walruses

Patrick Lemons
U.S. Fish and Wildlife Service, patrick_lemons@fws.gov
Suresh Sethi
U.S. Fish and Wildlife Service, suresh_sethi@fws.gov
Jeffrey Olsen
U.S. Fish and Wildlife Service, jeffrey_olsen@fws.gov
Jason Everett
U.S. Fish and Wildlife Service, jason_everett@fws.gov
Cara Lewis
U.S. Fish and Wildlife Service, cara_lewis@fws.gov
Joel Garlich-Miller
U.S. Fish and Wildlife Service, joel_garlichmiller@fws.gov
Lori Quakenbush
Alaska Department of Fish & Game, lori.quakenbush@alaska.gov
Geoffrey Cook
U.S. Fish and Wildlife Service, geoffrey_cook@fws.gov
James MacCracken
U.S. Fish and Wildlife Service, james_maccracken@fws.gov
Sergey Zagrebelnny
ChukotTINRO, tryton2011@mail.ru
Eduard Zdor
Association of Traditional Marine Mammal Hunters of Chukotka, eduard.zdor@gmail.com
John Wenburg
U.S. Fish and Wildlife Service, john_wenburg@fws.gov

The Pacific walrus is an ice associated pinniped that inhabits continental shelf waters of the Bering and Chukchi Seas. The amount of sea ice habitat available to walruses has declined over the last 30 years as a result of global climate change and this trend is predicted to continue. The decline in sea ice habitat and the associated stressors are predicted to cause a population decline and this has resulted in walruses being listed as a candidate species under the Endangered Species Act in 2011. The paucity of information pertaining to abundance and population demographic rates of walruses makes it difficult to monitor and manage the population in a changing environment. Furthermore, management of subsistence harvest of Pacific walrus under the Marine Mammal Protection Act requires an understanding of abundance and demographic rates, both of which are lacking. In 2013 the U.S. Fish and Wildlife Service initiated a large scale study to determine the feasibility of genetics based capture-mark-recapture approach for estimation of abundance and demographic rates. The biggest hurdle to the success of this project was the minimum sample size requirement, or the annual collection 1,300 skin biopsy samples from individual walruses for individual identification (i.e. genetic tagging). During the first three years of this project we

genetically tagged approximately 5,000 individuals, exceeding our minimum sample size requirements. Following the 2015 field effort, we generated preliminary estimates for the Pacific walrus population suggesting that this method is a viable means for estimating population size and demographic rates of the population.

Integration of Oceanographic Data with Fin Whale Calling Presence in the Bering Sea

Srishti Dasarathy
NOAA, Alaska Fisheries Science Center, srishti.dasarathy@noaa.gov
Catherine Berchok
NOAA, Alaska Fisheries Science Center, catherine.berchok@noaa.gov
Phyllis Stabeno
NOAA, Pacific Marine Environmental Laboratory, phyllis.stabeno@noaa.gov
Jessica Crance
NOAA, Alaska Fisheries Science Center, jessica.crance@noaa.gov

Through the integration of environmental data with passive acoustic monitoring, it is possible to investigate whether fin whale (*Balaenoptera physalus*) presence is influenced by environmental factors. Fin whale calling activity and concurrent environmental variables were analyzed from May 2012 to September 2013. These data were collected from passive acoustic and oceanographic moorings located in the Bering Sea. Fin whale calling presence was strongly correlated with three of the eight parameters analyzed: ice concentration, chlorophyll (a proxy for primary production), and temperature. Fin whale calling was negatively correlated with ice concentration; as ice concentration increased, fin whale calling decreased. A strong positive correlation was observed between fin whale calling and chlorophyll. A large spike in chlorophyll concentration in July 2013 preceded fin whale calling at the northern location. Fin whale calling also increased concurrently with a mixing of the water column (evidenced in the temperature data) at a depth of 30 to 50 m. Peaks in chlorophyll concentration occurred after the mixing of the water column, and followed an increase in fin whale calling. These data illustrate the relationship between fin whale presence and environmental variables in the Bering Sea. These correlations may be used to predict the impact of climate change on fin whale populations in the rapidly changing environment of the Bering Sea.

Using Vocal Dialects to Assess the Population Structure of Bigg's Killer Whales in Alaska

Deborah Sharpe
Alaska Pacific University, dsharpe@alaskapacific.edu
Paul Wade
NOAA, Alaska Fisheries Science Center, paul.wade@noaa.gov
Manuel Castellote
NOAA, Alaska Fisheries Science Center, manuel.castellote@noaa.gov
Leslie Cornick
Alaska Pacific University, lcornick@alaskapacific.edu

Apex predators are important indicators of ecosystem health, but little is known about the population structure of Bigg's killer whales (*Orcinus orca*; i.e. "transient" ecotype) in western Alaska. Currently, all Bigg's killer whales in western Alaska are ascribed to a single broad stock for management under the U.S. Marine Mammal Protection Act. However, recent nuclear microsatellite and mitochondrial DNA analyses indicate that this stock is likely comprised of genetically distinct sub-populations. Stock structure is critical information needed for proper conservation management. In accordance with what is known about group-specific killer whale vocal dialects in other locations, we sought to evaluate and refine Bigg's killer whale population structure by using acoustic recordings to examine the spatial distribution of call types in western Alaska. A total of 55 hours of digital audio recordings were collected from 33 encounters with Bigg's killer whales throughout the Aleutian and Pribilof Islands in the summers of 2001-2007 and 2009-2010, then visually and aurally reviewed using the software *Adobe Audition*. High quality calls were identified and classified into discrete call types based on spectrographic characteristics and aural uniqueness. A comparative analysis of call types recorded throughout the study area revealed spatial segregation of call types, corresponding well with proposed genetic delineations. These results suggest that Bigg's killer whales exhibit regional vocal dialects, which can be used to help refine the putative sub-populations that have been genetically identified throughout western Alaska. Our findings support the proposal to restructure current stock designations.

Thinking Strategically in the Aleutian Archipelago

Douglas Burn
Aleutian and Bering Sea Islands Landscape Conservation Cooperative, Douglas_Burn@fws.gov
Martin Robards
Aleutian and Bering Sea Islands Landscape Conservation Cooperative, mrobards@wcs.org
Aaron Poe
Aleutian and Bering Sea Islands Landscape Conservation Cooperative, Aaron_poe@fws.gov

Each year, thousands of deep-draft vessels transit through the Aleutians along shipping routes between North America and Asia. In December 2004 the M/V *Selendang Ayu*, a 740-foot bulk carrier, lost power and drifted aground on the north shore of Unalaska Island in the eastern Aleutians. The vessel was broken in two, spilling over 300,000 gallons of heavy fuel oil and cargo of soybeans. The resulting disaster claimed the lives of six crewmen, as well as thousands of seabirds and at least six sea otters. Our comprehensive analysis of these shipping routes documented that many of these ships pass perilously close to several of the Aleutian islands. Those results helped inform a proposal by the U.S. Coast Guard to the International Maritime Organization (IMO) for the establishment of five Areas to be Avoided (ATBAs) in the Aleutians. These ATBAs would apply to ships 400 gross tons and heavier, transiting on the Great Circle Route on either the north or south side of the Aleutian archipelago. The proposal was approved by the IMO in June 2015 and takes effect on January 1, 2016. Further analysis of new vessel routes that would conform to the proposed ATBAs using distance as a proxy for exposure indicates that the new routes would reduce potential risk to seabird colonies by 17% and to endangered Steller sea lions at haulouts and rookeries by 21%, while adding less than 1% to the overall length of the voyage between the two continents. Additional analysis supported by the ABSI partnership will identify areas most at risk to vessel drift groundings, which can inform spill response preparation efforts. There are enormous economic benefits for vessel operators to reduce the risk of impacts to natural resources such as marine mammals and seabirds.

Testing Sociocultural Impacts of Declining Chinook Salmon Runs on Yukon River Communities

Hillary Hafner
Alaska Pacific University, hafnerhillary@gmail.com
Pamela Maslyk
Alaska Pacific University, mathpam@alaskapacific.edu
Toshihide Hamazaki
Alaska Department of Fish & Game, toshihide.hamazaki@alaska.gov

Since the 1990s, Chinook salmon runs on the Yukon River have declined greatly, resulting in the collapse of commercial Chinook salmon fisheries and severe restrictions and closures of subsistence Chinook salmon fisheries in 1998, 2000, 2009, and 2012-2014. Those restrictions are perceived to have had substantial socio-economic impacts on the people in Yukon River communities, which have been expressed in public testimonies and published in numerous news articles as well as state and federal reports. For instance, the United States Department of Justice released a report stating that violence spikes during times when Alaska Natives are unable to engage in traditional subsistence hunting and fishing activities. Here, we attempt to substantiate those claims through statistical analysis of available socio-economic data. Based on the claims we expect that socio-economic indices would worsen during years of restrictions. Socio-economic data (population size, dropout rate, crime frequency, employment, annual income, and subsistence salmon harvest) were obtained from various agencies and institutions (ALRI, ISER, ADPS, ADFG) in following villages: Alatna, Alakanuk, Emmonak, Nunam Iqua, Marshall, St. Mary, Holy Cross, Russian Mission, Shageluk, Anvik, Galena, Grayling, Huslia, Kaltag, Koyukuk, Nenana, Nulato, Ruby, Beaver, Birch Creek, Central, Rampart, Tanana, Steven's Village, Circle, Fort Yukon, Eagle. Chinook salmon subsistence harvest rate (harvest per capita) were not statistically correlated with none of socio-economic data (Pearson coefficient of correlation $P > 0.05$), except for average wage (both positive and negative) in some villages. During years of restrictions, rate of total and violent crime increased in 8 villages but decreased in 12 villages; however, none of the difference was statistically significant (Wilcoxon signed rank test $P > 0.05$).Those findings did not change even when individual villages were combined by fishing district, as well as all were combined. In conclusion, we were unable to find any statistical evidence substantiating the claims of the impacts of subsistence Chinook salmon harvests decline and restrictions on socio-economic indices obtained in the Yukon River villages. This is the first study attempting to examine the impacts quantitatively. Further studies are greatly warranted.

Broken Links: How Limited Entry, Markets, and Family Have Transformed Access to and Participation in Bristol Bay's Commercial Fisheries

Jesse Coleman
University of Alaska Fairbanks, jmcoleman2@alaska.edu

Between 1980 and 2013, the number of Bristol Bay limited entry permit holders under the age of 40 has decreased by 47%. More than just a piece of demographic trivia, this statistic underscores the increasingly restricted opportunities for ownership-level commercial fishing careers available to young Bristol Bay residents. Our research team seeks to understand the perceived barriers to entry that exist for the next generation of commercial fishermen, and how entry processes have changed over time. We're using ethnographic research methods, including semi-structured interviews with new and experienced fishermen, and a survey of local students to elicit the attitudes held by young residents on commercial fishing in their communities. In this presentation, I will give background on limited entry in Bristol Bay, and discuss some of our results, including common interview themes of 1) family connections to the fisheries, 2) global seafood market dynamics, and 3) how permit and permit holder outmigration have changed young people's access to limited entry fisheries. As we continue the project, we hope to further untangle the complex, underlying issues that shape local fisheries participation and the sustainability of coastal communities in Bristol Bay.

Carbon Sources of Ice Seals During Recent Environmental Shifts in the Bering Sea

Shiway Wang
University of Alaska Fairbanks, shiway@gmail.com
Alan Springer
University of Alaska Fairbanks, amspringer@alaska.edu
Suzanne Budge
Dalhousie University, Suzanne.Budge@Dal.Ca
Lara Horstmann-Dehn
University of Alaska Fairbanks, lara.horstmann@alaska.edu
Lori Quakenbush
Alaska Department of Fish & Game, lori.quakenbush@alaska.edu
Matthew Wooller
University of Alaska Fairbanks, mjwooller@alaska.edu

Dramatic multiyear fluctuations in water temperature and seasonal sea ice extent and duration across the Bering-Chukchi continental shelf have occurred in this century, raising a pressing ecological question: do such environmental changes alter marine production processes linking primary producers to upper trophic level predators? We examined this question by comparing the blubber fatty acid (FA) composition and stable carbon isotope ratios of individual FA ($d^{13}C_{FA}$) of adult ringed seals (*Pusa hispida*), bearded seals (*Erignathus barbatus*), and spotted seals (*Phoca largha*) sampled during an anomalously warm, low sea ice period in 2002–2005 in the Bering Sea and a subsequent cold, high sea ice period in 2007–2010. $d^{13}C_{FA}$ values, used to estimate the contribution to seals of carbon derived from sea ice algae (sympagic production) relative to that derived from water column phytoplankton (pelagic production), indicated that during the cold period sympagic production accounted for 62% – 80% of the FA in the blubber of bearded seals, 51% – 62% in spotted seals, and 21% – 60% in ringed seals. Moreover, the $d^{13}C_{FA}$ values of bearded seals indicated a greater incorporation of sympagic FAs during the cold period than the warm period. This result provides the first empirical evidence of an ecosystem scale effect of a putative change in sympagic production in the Western Arctic. Despite interannual variability, the FA composition of ringed and bearded seals showed little evidence of differences in diet between the warm and cold periods. The findings that sympagic production contributes significantly to food webs supporting ice seals, and that the contribution apparently is less in warm years with low sea ice, raise an important concern: will the projected warming and continuing loss of seasonal sea ice in the Arctic, and the associated decline of organic matter input from sympagic production, be compensated for by pelagic production to satisfy both pelagic and benthic carbon and energy needs?

Jellyfish - Fish Trophic Interactions in the Bering Sea: Ecosystem Impacts of Jellyfish Population Fluctuations

James Ruzicka
Oregon State University, jim.ruzicka@oregonstate.edu
Kristin Cieciel
NOAA, Alaska Fisheries Science Center, kristin.cieciel@noaa.gov
Mary Beth Decker
Yale University, marybeth.decker@yale.edu
Richard Brodeur
NOAA, Northwest Fisheries Science Center, rick.brodeur@noaa.gov

Populations of scyphozoan jellyfish in the eastern Bering Sea (EBS) can grow rapidly within a single season and have fluctuated widely over recent decades. Understanding the role of jellyfish in the EBS ecosystem is required for fishery and ecosystem management, however we lack direct measurements of the impact that changes in jellyfish abundance have had upon this ecosystem and its fish populations. In our NPRB-funded project, we are examining the role of jellyfish as competitors, predators, and ecosystem structuring agents. These goals are being achieved by: (1) observing the diets and measuring the consumption demands of the dominant scyphozoan jellyfish in the region, *Chrysaora melanaster*, (2) estimating the dietary and spatial overlaps between jellyfish and major planktivorous fish groups (e.g., forage fishes, age-0 walleye pollock, and juvenile salmon), (3) simulating the direct and indirect impacts of jellyfish variability throughout the food web via large-scale ecosystem models, and (4) examining interannual relationships between indices of jellyfish biomass and indices of fish production. Ocean sampling for diet and digestion analyses occurred in 2014, 2015 and will continue in 2016. Jellyfish diets in 2014 consisted mainly of pteropods and showed little overlap with the forage species. Fishery survey data were used to examine the spatial overlap of forage fish and jellyfish within the EBS between 2004-2012, a period that includes both warm and cool ocean conditions. Generally, jellyfish and forage fishes have low spatial overlap. However, spatial overlap and trophic relations are not uniform throughout the EBS nor across years, regions of high overlap do occur, especially in warm years. To estimate the impacts of changing jellyfish abundances and levels of spatial and diet overlap with other planktivores (forage fishes and juvenile salmon), we have developed a spatially resolved trophic model for three coupled, cross-shelf regions. Models have been separately configured for “warm” (2001-2006) and “cool” (2007-2010) periods using Alaska Fisheries Science Center pelagic and demersal survey data. Preliminary analyses suggest that over the last decade, jellyfish require 11-fold more energy from the ecosystem than do the forage fish populations while passing along only 4% as much energy to the higher food web.

Early Warning Indicators to Track Resilience in the Bering Sea Ecosystem

Mike Litzow
Farallon Institute for Advanced Ecosystem Research, litzow@faralloninstitute.org
Bob Lauth
NOAA, Alaska Fisheries Science Center, bob.lauth@noaa.gov

What if managers had early warning that a sudden shift in exploited stocks was imminent? This is the promise of the rapidly growing field of “early warning indicators” (EWI) for ecological tipping points. However, EWI remain primarily theoretical, and the degree to which they might be useful in real ecosystems remains unclear. We used the 2006-13 cold anomaly in the Bering Sea as a natural experiment to test proposed EWI. During this cold period, the Bering Sea community showed signs of hysteresis – delayed, non-linear response to the cold perturbation that differed from the community response to cold in the 1970s. In this situation, theory predicts that EWI will signal declining resilience as a persistent perturbation pushes the community towards a tipping point. We applied three proposed EWI (rising spatial variance, rising spatial correlation and rising temporal autocorrelation) to CPUE data from the NOAA Bering Sea bottom trawl survey (1982-2015) to test this prediction. Our analysis included 19 groundfish and crustacean taxa. Of the resulting 57 taxon-EWI time series, 19 showed significant increases during 2006-2013 (community-wide randomization test, $p < 0.001$). When temperatures warmed in 2014-15, EWI reverted to their long-term levels. These results are consistent with declining resilience in the contemporary warm state community during a cold period, and provide an example of how EWI may enhance the information provided by an existing trawl survey. We review other examples of EWI in Alaska, and consider the ways in which these tools might contribute to fisheries management.

Plenary Sessions – Thursday, January 28

Plenary Sessions: Thursday, January 28 -- Gulf of Alaska

TIME	TITLE	PRESENTER	SECTION
8:00 - 8:15 AM	More Robust Projections of Freshwater Fluxes into the Gulf of Alaska Under Climate Change: An Intercomparison of Coupled Hydrologic-Cryosphere Models	Thomas Mosier *	Climate and Oceanography
8:15 - 8:30 AM	Climate Change Impacts on Alaskan Hydrology and Freshwater Discharge	Jordan Beamer *	Climate and Oceanography
8:30 - 8:45 AM	An OA Lighthouse for the Shellfish Aquaculture Industry in the State of Alaska: Alutiiq Pride Shellfish Hatchery	Wiley Evans	Climate and Oceanography
8:45 - 9:00 AM	Surface Layer and Bloom Dynamics in Prince William Sound	Robert Campbell	Climate and Oceanography
9:00 - 9:15 AM	The Effects of the Anomalous Warming on Lower Trophic Levels in the Gulf of Alaska from Continuous Plankton Recorder Sampling.	Sonia Batten	Lower Trophic Levels
9:15 - 9:30 AM	Early Life History Ecology for Five Commercially and Ecologically Important Fish Species in the Eastern and Western Gulf of Alaska in 2011 and 2013	Elizabeth Siddon	Lower Trophic Levels
9:30 - 10:00 AM	**BREAK**		
10:00 - 10:15 AM	Can Fishing Explain Declines in Size-at-Age of Pacific Halibut?	Jane Sullivan *	Fishes and Fish Habitats
10:15 - 10:30 AM	Pre-settlement Processes of Northern Rock Sole (*Lepidopsetta polyxystra*) in Relation to Interannual Variability in the Gulf of Alaska	Erin Fedewa *	Fishes and Fish Habitats
10:30 - 10:45 AM	How Does Release Density Affect Enhancement Success for Hatchery-reared Red King Crab?	William Long	Fish and Invertebrates
10:45 - 11:00 AM	Ecological Factors Influencing the Overwinter Survival of Age-0 Herring in Prince William Sound, Alaska	Ron Heintz	Fish and Invertebrates
11:00 - 11:15 AM	The Influence of Ocean Productivity on Stress and Parental Investment in a Long-lived Seabird	Anne Schaefer	Seabirds
11:15 - 11:30 AM	Does the Warm Water Blob Explain Seabird Die-offs and Low Reproductive Success in 2015?	Heather Renner	Seabirds
11:30 - 1:00 PM	**BREAK - LUNCH PROVIDED**		

* Masters; ** Doctorate

Plenary Sessions: Thursday, January 28 -- Gulf of Alaska

TIME	TITLE	PRESENTER	SECTION
1:00 - 1:15 PM	Non-breeding Distributions and Spatial Ecology of Rhinoceros Auklets from Colonies in Alaska and British Columbia, with Implications for Management	Katharine Studholme *	Seabirds
1:15 - 1:30 PM	Using Remote Techniques to Identify Factors Influencing Annual Productivity of a Colony of Black-legged Kittiwakes (*Rissa tridactyla*) in the Northern Gulf of Alaska	Sarah Tanedo *	Seabirds
1:30 - 1:45 PM	Expanding Their Range and the Depredation Problem, Sperm Whales Enter New Habitat in Chatham Strait, Inside Waters of Southeast Alaska	Russel Andrews	Marine Mammals
1:45 - 2:00 PM	Seasonal Distribution and Foraging Behavior of Cook Inlet Beluga Whales	Robert Small	Marine Mammals
2:00 - 2:15 PM	Where Science Meets Policy: Protected Species Permitting and Take Estimation	Sarah Courbis	Marine Mammals
2:15 - 2:30 PM	Filling in the lanks: multidisciplinary approaches for addressing critical data gaps in our understanding of the structure of Southeast Alaska harbor porpoise (*Phocoena phocena*).	Kim Parsons	Marine Mammals
2:30 - 2:45 PM	Managing the Invasive Tunicate, *Didemnum vexillum* , in Alaska	Ian Davidson	Human Dimensions
2:45 - 3:15 PM	**BREAK**		
3:15 - 3:30 PM	Graying of the Fleet in Kodiak's Fisheries: Defining the Problem and Assessing Solutions	Rachel Donkersloot	Human Dimensions
3:30 - 3:45 PM	Examining the Effects of Herring Fishing Strategies on a Northeast Pacific Ecosystem	Szymon Surma *	Ecosystem Perspectives
3:45 - 4:00 PM	The Effects of Rising Sea Surface Temperature and Decreasing Salinity on Kelp Forest Ecosystems	Alyssa Lind *	Ecosystem Perspectives
4:00 - 4:15 PM	Gulf Watch Alaska in Hot Water! Ecological Patterns in the Northern Gulf of Alaska under the Pacific 2014-2015 Warm Anomaly	Tammy Hoem Neher	Ecosystem Perspectives
4:15 - 4:45 PM	Gulf of Alaska Project: The Gauntlet Games - Final Showdown	Russell Hopcroft	Ecosystem Perspectives
4:45 - 5:00 PM	**Best Student Oral Presentations Winners Announced**		
5:00 - 5:15 PM	**CLOSING REMARKS**		
FRIDAY - ALL DAY	**AMSS 2016 Workshops – http://amss.nprb.org/program-schedule/workshops/**		

Plenary Session Abstracts

Thursday, January 28

More Robust Projections of Freshwater Fluxes into the Gulf of Alaska Under Climate Change: An Intercomparison of Coupled Hydrologic-Cryosphere Models

Thomas Mosier
Oregon State University, mosier.thomas@gmail.com
David Hill
Oregon State University, dfh@engr.oregonstate.edu
Kendra Sharp
Oregon State University, kendra.sharp@oregonstate.edu

Freshwater fluxes into the Gulf of Alaska (GOA) play a critical role in maintaining the health of GOA ecosystems. Much of the freshwater that eventually drains into the GOA originates as snow and ice. The timing and magnitude of freshwater releases from these sources will likely change as a result of climate change, and understanding the range of possible changes is necessary to help prevent and mitigate potential impacts. Due to the sparsity of climate data products for Alaska, studies of freshwater fluxes into a large portion of the GOA often use regression formulations or conceptual models. These model types are useful for studying freshwater fluxes under current climate conditions but cannot reliably project snow and glacier responses to climatic conditions outside of the regime for which the model was calibrated. Energy balance models are more robust for characterizing impacts of climate change, but are generally not used for large spatial domains in Alaska because they require extensive data inputs that are typically unavailable. To mitigate the disparity between data availability and the need for a model that robustly reproduces hydrologic changes under an altered climate, we have developed a novel model, the Significantly Enhanced Temperature Index (SETI) model. The SETI model is formulated to be both straightforward to implement in the Alaskan context and more explicitly capture physical snow and glacier processes, enabling it to better capture the spatial and temporal patterns of freshwater fluxes under present and projected future climates. We quantitatively compare the SETI model to two existing conceptual models, the simple degree index (SDI) and enhanced temperature index (ETI), for the Wolverine and Gulkana long-term study glaciers. For each glacier we compare the models' abilities to reproduce glacier mass changes, snow cover, and streamflow. Under this analysis, the SETI model is seen to be more temporally and spatially robust than the previously available SDI and ETI models. We therefore use the SETI model to create climate change projections of freshwater fluxes using an ensemble of global climate models (GCMs) for representative concentration pathways 4.5 and 8.5.

Climate Change Impacts on Alaskan Hydrology and Freshwater Discharge

Jordan Beamer
Oregon State University, beamerj@oregonstate.edu
David Hill
Oregon State University, dfh@engr.oregonstate.edu

This research will produce an ensemble of distributed freshwater discharge (FWD) data along the Gulf of Alaska (GOA) coastline for future climate and land cover scenarios using a proven distributed hydrological model. This improves our understanding of the land-to-ocean water flux delivered from the mountain environments and will provide important information on boundary conditions for near-shore marine ecosystems of the GOA. In addition, we will determine what controls the partitioning of runoff among contributing sources (rainfall, snow-melt, ice-melt) in mountain regions and to identify the pathways for change of this partitioning in the future. We build upon recent success in modeling historical runoff conditions by leveraging a physical, process based modeling system adapted, validated, and improved for the GOA watershed, along with the associated weather and land cover datasets. We conduct modeling efforts that utilize an ensemble of global climate models (GCMs) and systematically altered land cover to reveal the major mechanisms for hydrological change and how hydrologic partitioning will be altered. A 30 year record of weather data from Climate Forecast System Reanalysis (CFSR) in combination with five top-performing CMIP5/AR5 GCMs and two emission scenarios (RCP 4.5 and 8.5) will produce 10 plausible climate responses for a future period (2071-2100). The relative contributions of rainfall, snow-melt and ice-melt to the coastal runoff, important for biophysical parameters such as stream water temperature and nutrient concentrations, will be quantified over the entire runoff season. The spatial variation of this mix of hydrologic sources across the GOA will be identified, and this information used to assess how freshwater discharge and its constituent source waters will change in the future. This is the most detailed effort thus far to model runoff along the GOA coastline, and the first effort to comprehensively model climate-change alterations to this runoff.

An OA Lighthouse for the Shellfish Aquaculture Industry in the State of Alaska: Alutiiq Pride Shellfish Hatchery

Wiley Evans
Hakai Institute, wiley.evans@hakai.org
Burke Hales
Oregon State University, bhales@coas.oregonstate.edu
Jacqueline Ramsay
Alutiiq Pride Shellfish Hatchery, jacqueline@alutiiqpridehatchery.com
Jeff Hetrick
Alutiiq Pride Shellfish Hatchery, jjh@seward.net
Jeremy Mathis
NOAA Arctic Research Program, jeremy.mathis@noaa.gov

The invasion of anthropogenic carbon dioxide (CO_2) into the ocean is progressively shifting the marine carbonate system such that the saturation states of calcium carbonate ($CaCO_3$) minerals are decreasing. This global scale secular change is occurring in conjunction with large natural variability in coastal settings, which acts to shift the envelope of variability leading to longer and more frequent exposure to adverse conditions. These changes are a great concern in the State of Alaska, a high-latitude setting vulnerable to rapid modifications in the marine carbonate system due to anthropogenic CO_2 invasion and where an emerging shellfish industry plans major growth over the coming decades. At the Alutiiq Pride Shellfish Hatchery (APSH) in Seward, Alaska, marine carbonate system variability has been tracked since October 2013. Measurements made at APSH detail trends in the saturation state of aragonite (Ω_{arag}), the more soluble form of $CaCO_3$, from intake water near continuously over a two-year period. The initial 10 months of data have been published and describe changes over the seasonal time scale. Specifically, these data pinpoint a 5-month window of favorable Ω_{arag} conditions for growing early life stages of vulnerable shellfish species that is estimated to close by 2040. The latter portion of the record is accessible through the U.S. Integrated Ocean Observing System (IOOS) Pacific Region Ocean Acidification (IPACOA) data portal, which provides data streams from a number of shellfish hatcheries from Alaska to California. This talk will describe results from the early data collected at APSH, trends in the newer data hosted on IPACOA, and a newly funded project to expand the measurement capacity to include analyzing discrete samples collected from neighboring villages to Seward as well as develop a dosing system to test species responses to carbonate system conditions resulting from ocean acidification.

Surface Layer and Bloom Dynamics in Prince William Sound

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

As part of the Gulf Watch Alaska long-term monitoring effort, deployments of a WETLabs Autonomous Moored Profiler (AMP) began in Prince William Sound (PWS) in 2013. The PWS AMP consists of a positively buoyant instrument frame with an onboard winch and associated electronics that profiles the frame from a park depth (usually ~ 55 m) to the surface by paying out and hauling back a thin tether; it generally conducts a daily cast and measures temperature, salinity, chlorophyll-a fluorescence, turbidity, and oxygen and nitrate concentrations. Upward and downward looking acoustic Doppler current meters are mounted on a float below the profiler. Deployments in 2014 and 2015 have produced an unprecedented time series of the seasonal progression of the hydrography and biogeochemistry in the surface waters of PWS.

The northern Gulf of Alaska has experienced a widespread warm anomaly since early 2014, and surface layer temperature anomalies in PWS were strongly positive during winter 2014. The spring phytoplankton bloom began 2-3 weeks earlier than average, with surface nitrate depleted by late April. Although surface temperatures were still above average in 2015, bloom timing was much later, with a short vigorous bloom in late April and a subsurface bloom in late May that coincided with significant nitrate drawdown. As well as the vernal blooms, wind-driven upwelling events lead to several small productivity pulses that were evident in changes in nitrate and oxygen concentrations, and chlorophyll-a fluorescence. As well as providing a mechanistic understanding of surface layer biogeochemistry, high frequency observations such as these put historical observations in context, and provide new insights into the scales of variability in the annual cycles of the surface ocean in the North Pacific.

The Effects of the Anomalous Warming on Lower Trophic Levels in the Gulf of Alaska from Continuous Plankton Recorder Sampling

Sonia Batten
Sir Alister Hardy Foundation for Ocean Science, soba@sahfos.ac.uk

Continuous Plankton Recorders (CPRs) were first deployed in the Gulf of Alaska in 2000 so that there is now a 15 year time series of taxonomically resolved, lower trophic level abundance data. During this time the ocean has experienced periods of warmer and colder conditions, as indexed by the Pacific Decadal Oscillation, with noticeable responses in the plankton such as a higher abundance of warm water species and a more northerly distribution in warm years, or a later spring zooplankton increase in colder years. This presentation will compare 2014/15 data, collected during the anomalous warming, with the preceding time series. Preliminary findings suggest that some of the planktonic responses to the anomalous warming were in-line with previous warm conditions in the mid-2000s, but some were not. For example: The larger diatoms that the CPR samples were unusually low in both region and comprised a higher proportion of long, narrow cells than normal. Zooplankton biomass was very high through 2014 on the Alaskan shelf and the previously strong positive relationship between diatoms and zooplankton biomass did not hold true in 2014. Warm water copepods were more numerous in both regions than in recent cold years, but not as numerous as expected in the open ocean. Some speculative conclusions will be drawn and it is hoped that these data can contribute to a larger understanding of the impact of the unusual conditions on the Gulf of Alaska marine ecosystem.

Early Life History Ecology for Five Commercially and Ecologically Important Fish Species in the Eastern and Western Gulf of Alaska in 2011 and 2013

Elizabeth Siddon
NOAA Alaska Fisheries Science Center, elizabeth.siddon@noaa.gov
Lisa DeForest
NOAA Alaska Fisheries Science Center, Lisa.DeForest@noaa.gov
Debbie Blood
NOAA Alaska Fisheries Science Center, Debbie.Blood@noaa.gov
Miriam Doyle
NOAA Alaska Fisheries Science Center, Miriam.Doyle@noaa.gov
Ann Matarese
NOAA Alaska Fisheries Science Center, Ann.Matarese@noaa.gov

The Gulf of Alaska Integrated Ecosystem Research Program was a multi-disciplinary study examining interactions between physical and biological oceanography to understand how the environment influences the survival and recruitment of early life stages of selected commercially and ecologically important groundfish species. Biological and oceanographic surveys in the eastern and western Gulf of Alaska (GOA) were conducted during spring and summer of 2011 and 2013; we present a synthesis of ichthyoplankton data collected. The results describe regional (eastern vs. western GOA) and interannual (2011 vs. 2013) variation in distribution, abundance, and larval sizes of the focal species. Pacific cod (*Gadus macrocephalus*) larvae occurred primarily in the western GOA near Kodiak Island, over the shelf, and at the slope; larvae were significantly more abundant in 2013 than 2011. Walleye pollock (*Gadus chalcogrammus*) larvae were also more abundant in the western GOA, with substantially higher abundance in 2013. Pollock larvae were collected over the shelf and at the slope; in 2013 concentrations of larvae were associated with troughs that intersect the shelf. Sablefish (*Anoplopoma fimbria*) larvae, however, were more abundant in the eastern GOA and in 2011. Larval sablefish were predominantly collected near areas of deep water. In 2011, larval Arrowtooth flounder (ATF; *Atheresthes stomias*) abundances were higher in the western GOA, whereas in 2013 abundances were higher in the eastern GOA. ATF larvae were collected primarily along the slope and near canyons and troughs. Larval rockfish (predominantly Pacific ocean perch; *Sebastes alutus*) were collected in deep water or associated with the slope, troughs intersecting the slope, and the outer shelf. Rockfish were ubiquitous throughout the study region with no significant differences in abundance between regions or years. Results from 2011 and 2013 are compared with long-term prevailing patterns from the western GOA. The results from individual years presented here may be used in IBM model validation of connectivity matrices, transport patterns to suitable nursery habitat, and recruitment “gauntlets” for

these focal species in the Gulf of Alaska. These patterns provide insight into how environmental forcing may influence early life history aspects of recruitment.

Can Fishing Explain Declines in Size-at-Age of Pacific halibut?

Jane Sullivan
University of Alaska Fairbanks, jysullivan@alaska.edu
Steven Martell
International Pacific Halibut Commission, stevem@iphc.int
Gordon Kruse
University of Alaska Fairbanks, ghkruse@alaska.edu

The biomass of Pacific halibut (*Hippoglossus stenolepis*) has been declining since the late 1990s. Reductions in size-at-age explain more than half of the observed decline in halibut biomass. For example, in the 1980s an age-20 female halibut weighed 135 pounds on average, and in 2014 an age-20 female weighed less than 45 pounds. One possible explanation for declines in size-at-age is the cumulative effects of size-selective fishing. Under this hypothesis, fast growing halibut have a higher total mortality rate relative to slow growing halibut because they recruit to the minimum legal size limit at a much younger age. The net result is a population that consists of primarily slower growing individuals. We used an age- and size-structured equilibrium model to examine the relationship between fishing mortality and size-at-age. We fit a von Bertalanffy growth model for each sex to size-at-age data collected from a fisheries-independent survey during the 1980s (a period when size-at-age peaked) and used these growth parameters to define the mean size-at-age and variability in size-at-age in the equilibrium model. Fishing mortality was modeled as a function of length, and the effects of fishing mortality and discard mortality were jointly considered in the analysis. Results were evaluated in terms of changes in mean weight-at-age with fishing mortality under equilibrium conditions. Realized exploitation rates of all fisheries combined ranged from 25% to 49% from 1996 to 2014, with a mean of 34%. For an exploitation rate of 34%, preliminary results suggest that cumulative effects of size-selective fishing explain 30% to 65% of the observed declines in size-at-age since the 1980s, depending on sex and age. Model results are sensitive to the coefficient of variation in size-at-age, discard mortality rates, and fisheries selectivity. Reduced size-at-age as a consequence of size-selective fishing has management implications on the commercial fishery, including minimum legal size limits and MSY-based reference points used to set annual catch quotas.

Pre-settlement Processes of Northern Rock Sole (*Lepidopsetta polyxystra*) in Relation to Interannual Variability in the Gulf of Alaska

Erin Fedewa
Oregon State University, erin.fedewa@oregonstate.edu
Jessica Miller
Oregon State University, jessica.miller@oregonstate.edu
Thomas Hurst
NOAA Alaska Fisheries Science Center, thomas.hurst@noaa.gov

Understanding the effects of climate variability on growth dynamics and timing of early life history events in marine fishes can provide insights into survival, recruitment and productivity. We examined interannual variation in larval growth rates, size at hatch and metamorphosis, and the timing of metamorphosis of northern rock sole (*Lepidopsetta polyxystra*) over 5 years in two nurseries at Kodiak Island, Alaska, USA. Variation in early life characteristics was quantified using laboratory-validated otolith structural analysis and related to water temperature and spring bloom dynamics in the Gulf of Alaska. Overall, results indicated that temperature contributed more to interannual variation in northern rock sole growth, size and phenology patterns than phytoplankton dynamics. Size at hatch was positively related to winter-spring spawning temperatures. Larval growth metrics were generally consistent with thermal effects and temperatures above 4° C appear necessary, but not sufficient to support fast growth. Reflecting the cumulative effects of temperature, the timing of metamorphosis was related to both seasonal and interannual variation in temperature with earlier dates of metamorphosis in warmer years. Conversely, fish size at metamorphosis was similar across years, suggesting that the competency to metamorphose is related to attainment of a minimum size. These results demonstrate the important role of temperature on regulating early life history phenology of northern rock sole and suggest that temperature-driven phenological shifts may also influence the timing of spawn and hatch.

How Does Release Density Affect Enhancement Success for Hatchery-reared Red King Crab?

William Long
NOAA Alaska Fisheries Science Center, chris.long@noaa.gov
Peter Cummiskey
NOAA Alaska Fisheries Science Center, peter.a.cummiskey@noaa.gov
J. Eric Munk
NOAA Alaska Fisheries Science Center, j.eric.munk@noaa.gov

Red king crab, *Paralithodes camtschaticus*, was an important fishery around Kodiak in the 1960s and 70s.However, in the late 1970s the stock crashed and the fishery was closed. Despite the closure, the population has failed to recover. A potential solution to help increase the population is the use of hatchery-reared juveniles to supplement the wild populations. In this study, we examine the effects of release density on the survival of hatchery-reared red king crab in the field. Juvenile red king crabs were reared at the Alutiiq Pride shellfish hatcher. They were released at three densities, 25, 50, and 75 m^{-2}, in replicate 5 x 5 m plots in Trident Basin, Kodiak alongside replicate control plots where no crabs were released. Densities both inside, to determine loss rates, and outside, to determine emigration rates, were monitored by divers for 5 months post release using quadrat counts. Relative predation risk was determined using tethering experiments that were repeated monthly for the first 3 months post-release, and predator densities were quantified using quadrat counts and predator transect counts. Initial mortality of crabs released into plots over the first 24 h was high, about 65%. Loss rates after the initial mortality did not differ among density treatments and were a combination of mortality and emigration. Relative predation risk was greater at night than during the day and decreased with time from release, but did not vary among density treatments. Predator density did not change over time and also did not vary with density treatment. Estimated mortality rates suggest that the mortality of hatchery-reared juveniles was similar to that of wild red king crabs in a healthy population, indicating that stock-enhancement may be ecologically viable. Future work should focus on ways to reduce initial release mortality and to maximize long-term survival.

The Influence of Ocean Productivity on Stress and Parental Investment in a Long-lived Seabird

Anne Schaefer
Prince William Sound Science Center, aschaefer@pwssc.org
Paul Lukacs
University of Montana, paul.lukacs@umontana.edu
Michelle Kissling
U.S. Fish and Wildlife Service, michelle_kissling@fws.gov
Stephen Lewis
U.S. Fish and Wildlife Service, steve_b_lewis@fws.org
Charline Parenteau
Center for Biological Studies of Chize, charline.parenteau@cebc.cnrs.fr
Olivier Chastel
Center for Biological Studies of Chize, chastel@cebc.cnrs.fr
Sara Berk
University of Montana, sara.berk@umconnect.umt.edu
Creagh Breuner
University of Montana, creagh.breuner@umontana.edu

Seabird demographic rates are sensitive to changes in prey availability; thus, it is important for managers to understand the environmental conditions experienced by seabirds throughout the year. Direct measures of prey abundance and availability are difficult to assess, particularly in the marine environment. Instead, physiological measurements can be used to understand the environmental conditions experienced by individuals from which population demographics may be predicted or inferred. We measured corticosterone (the primary avian stress hormone, CORT) in plasma and feather samples and prolactin (involved in parental expression) in plasma samples of an elusive seabird, the Kittlitz's murrelet (*Brachyramphus brevirostris*). We then evaluated relationships between measured hormone levels and breeding propensity and ocean productivity metrics (as proxies of food availability) during different times of the year. We found that higher feather CORT levels during the pre- and post-breeding seasons correlated with lower breeding propensity during the upcoming breeding season. In contrast, within the breeding season, higher levels of plasma CORT were associated with greater parental investment. Our results also suggest correlations between plasma CORT and environmental conditions, such as sea surface temperature, and individual-level characteristics, such as sex and body mass. Collectively, these results provide new insight regarding when Kittlitz's murrelets may make breeding decisions and how stress may influence those decisions, with conditions during the non-breeding season seeming to drive future reproductive decisions of murrelets more so than conditions experienced within the breeding season. The Kittlitz's murrelet is a highly visible, top predator in the marine environment. Therefore, understanding its response to environmental

conditions may provide insight into the responses of other predators that rely on similar resources.

Does the Warm Water Blob Explain Seabird Die-offs and Low Reproductive Success in 2015?

Heather Renner
U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, heather_renner@fws.gov
Kathy Kuletz
U.S. Fish and Wildlife Service, kathy_kuletz@fws.gov
Liz Labunski
U.S. Fish and Wildlife Service, elizabeth_labunski@fws.gov
Julia Parrish
University of Washington, jparrish@uw.edu
Barbara Bodenstein
U.S. Geological Survey, bbodenstein@usgs.gov
Hillary Burgess
University of Washington, hkb10@uw.edu

The Northeast Pacific Ocean experienced extreme temperature anomalies in 2014-2015, extending from Mexico to the Bering Sea. A persistent high pressure system reduced water circulation and produced an upper layer known widely as “the Blob”. Sea surface temperatures (SST) were roughly 2.5° C warmer than the long-term mean. SST is known to affect demographic parameters of seabirds and other upper trophic level predators, but often through unknown mechanisms and sometimes in contrasting directions. In summer 2015, there were widespread reports of marine wildlife die-offs, harmful algal blooms, and a large coccolithophore bloom in late summer in the Bering Sea. We compiled statewide reports of seabird die-offs and carcass numbers detected on beach surveys, as well as colony-based estimates of seabird reproductive success. Reported seabird mortality events were more widespread and frequent, and of longer duration than in previous years; at least 30 events occurred throughout the northern Gulf of Alaska (GOA) and the southern Bering Sea. Murres were the most commonly reported species. Beached bird surveys in the GOA indicated normal beaching rates across species for June and July, but were 2.5 times the long-term average in August; murres accounted for most of this difference. The primary finding for cause of death so far of necropsied carcasses has been emaciation, with no evidence of pathogenic viruses or bacteria; or algal toxicity results are still pending. At breeding colonies, seabirds showed mixed responses across foraging guilds and locations. Murres nested late and had an unprecedented complete reproductive failure in the western GOA, but higher than average reproductive success in Southeast Alaska and average in Resurrection Bay and the Aleutians. Kittiwakes had low reproductive success on most colonies monitored; in contrast, storm-petrels and cormorants had an average year. Puffins failed in the Aleutians but had average success in the GOA. Glaucous-winged gulls had an above average year at some colonies. It is likely that for many species, fewer birds nested than normal; this would not be evident in reproductive success rates. Future efforts should

focus on the mechanistic links between warming seas, at-sea mortality events and colony-based reproductive success.

Non-breeding Distributions and Spatial Ecology of Rhinoceros Auklets from Colonies in Alaska and British Columbia, with Implications for Management

Katharine Studholme
Dalhousie University, krstudholme@smcm.edu
J Mark Hipfner
Environment Canada, mark.hipfner@ec.gc.ca
Marie Auger-Méthé
Dalhousie University, auger-methe@Dal.Ca
Sara Iverson
Dalhousie University, Sara.Iverson@Dal.Ca
Glenn Crossin
Dalhousie University, Glenn.Crossin@Dal.Ca

Overwinter ecology has been little studied for many species of seabird, leaving knowledge gaps regarding their distributions, migratory phenology, non-breeding habitat preferences, and potential overlaps with anthropogenic stressors. Additionally, it is unknown whether these characteristics differ between populations and if such differences result in genetic structuring or dissimilarities in exposure to stressors. Such information could greatly improve the efficacy of management programs. To address these questions, I studied the spatial ecology of rhinoceros auklets breeding at six colonies in Alaska and British Columbia using light level geolocators deployed over the entire non-breeding period. Preliminary results suggest that individuals vary substantially in migratory strategy, at least partially independent of colony of origin. Birds from Alaskan colonies tended to make migrations south into coastal British Columbia but a few moved south offshore or remained resident in the Gulf of Alaska throughout the year. The majority of birds from British Columbian colonies migrated further south along the coast of the United States, as far as Mexico; however, some birds remained in coastal British Columbia, moved northward into Southeast Alaska, or visited all three regions before returning to their colony to breed. There is considerable overlap between the areas utilized by colonies throughout the annual cycle but further analyses are necessary to incorporate the temporal aspect of these movements. The results of these analyses, as well as habitat characteristics during stationary periods and spatiotemporal overlaps with potential anthropogenic stressors, will be presented. This work is part of an ongoing project linking distributions, overwinter ecology, physiological indicators of carryover effects, and reproductive investment in this species throughout its North American breeding range.

Using Remote Techniques to Identify Factors Influencing Annual Productivity of a Colony of Black-legged Kittiwakes (*Rissa tridactyla*) in the Northern Gulf of Alaska

Sarah Tanedo
University of Alaska Fairbanks, satanedo@alaska.edu
Tuula Hollmén
University of Alaska Fairbanks, tuulah@alaskasealife.org
Peter Winsor
University of Alaska Fairbanks, pwinsor@alaska.edu
Anne Beaudreau
University of Alaska Fairbanks, abeaudreau@alaska.edu

Annual seabird productivity, the measure of fledglings produced per nest attempt, has been proposed as an indicator of local ecosystem change. Productivity can fluctuate in response to multiple environmental factors, such as storm events or prey availability. Using productivity as an ecological indicator of change requires that efficient methods are established for long-term monitoring. Remote monitoring techniques offer a unique opportunity to consistently observe wildlife that inhabit remote locations with minimal disturbance and can be a useful tool for monitoring seabirds. The black-legged kittiwake (*Rissa tridactyla*, kittiwake), a small cliff-nesting species of gull, is a useful species for testing remote monitoring methods due to their widespread distribution and proclivity for nesting in high visibility locations. Refining remote monitoring techniques for observing breeding kittiwakes and using these methods to determine the influence of the local environment on annual success could serve as a framework for future projects. To investigate the suitability of remote methods to monitor cliff-nesting seabirds and their response to changes in the local environment, we used a remote video-camera system to collect 6 years (2010-2015) of target reproductive behavioral data from a sub-colony of kittiwakes in Resurrection Bay in Seward, Alaska. For our first objective, we investigated the influence of observation frequency and observation type on estimates of productivity. Results indicated that frequency (Friedman rank sum test, $t = 2.83$, $p = 0.07$) and type (Zero-inflated generalized linear mixed effects model, $z = 1.07$, $p = 0.287$) of observation did not significantly influence estimates of productivity, though increased time between monitoring periods resulted in a decline of productivity estimates. For our second objective, we examined the influence of seasonal and multi-year climate factors on annual reproductive success. Covariates for seasonal models included wind speed and direction, air temperature, and precipitation. Multi-year models tested the effects of sea surface temperature, salinity, and large-scale changes in weather patterns. Refining monitoring techniques and utilizing them to identify the relationship between annual reproductive success and changes in the local environment could provide an informative method for monitoring ecosystem health.

Expanding Their Range and the Depredation Problem, Sperm Whales Enter New Habitat in Chatham Strait, Inside Waters of Southeast Alaska

Russel Andrews
Alaska SeaLife Center, russa@alaskasealife.org
Linda Behnken
Alaska Longline Fishermen's Association, alfafish@acsalaska.net
Dan Falvey
Alaska Longline Fishermen's Association, myriadfisheries@gmail.com
Kristen Green
Alaska Department of Fish & Game, kristen.green@alaska.gov
Chris Lunsford
Ted Stevens Marine Research Institute, NOAA AFSC, chris.lunsford@noaa.gov
John Moran
Ted Stevens Marine Research Institute, NOAA AFSC, john.moran@noaa.gov
Victoria O'Connell
Sitka Sound Science Center, victoria.oconnell@gmail.com
Greg Schorr
Cascadia Research Collective, gschorr@cascadiaresearch.org
Andy Szabo
Alaska Whale Foundation, szabo@alaskawhalefoundation.org
Aaron Thode
Scripps Institution of Oceanography, athode@ucsd.edu
Lauren Wild
University of Alaska Fairbanks, lauren.a.wild@gmail.com
Jan Straley
University of Alaska Southeast, jan.straley@gmail.com

Since at least the mid-1970s adult male sperm whales have been removing sablefish from longline fishing vessels in the Gulf of Alaska. To better understand and mitigate this interaction, we've utilized photo-identification, acoustic monitoring, and satellite tagging. Initial results in Southeast Alaska showed sperm whales stayed close to the continental slope, with substantial depredation occurring in the federally-regulated sablefish fishery concentrated there. A smaller, State-regulated fishery occurs from mid-August to mid-November in inside waters, primarily in Chatham and Clarence Straits, but until 2008 there were no reports of depredation there. Sperm whales were not likely present in Chatham Strait before commercial whaling reduced their numbers in the North Pacific. However, every year since 2008, fishermen reported sperm whales in Chatham. In August 2010, two of the whales we tagged offshore, 237 km NNW of the southern entrance to Chatham Strait, traveled south and entered Chatham one week later. They spent over a month in southern Chatham, departing in October. In September 2014 we encountered these whales plus another in southern Chatham, and tagged two while they were depredating. We resighted them together in Chatham

1.5 months later. One whale's tag lasted 5.5 months, and it didn't depart Chatham until January, 1.5 months after the fishery closed. Its movements included all of Chatham and northern Lynn Canal, well beyond typical sablefish habitat. Although the whales might have moved into Chatham because of the presence of longline vessels, they have quickly learned to exploit the new territory. During the fishery, daily position updates of these whales were provided to interested fishermen, and those receiving updates used them to successfully avoid whale interactions. We estimate that at least four but not likely more than six whales are entering Chatham, making it a more manageable challenge than the offshore fishery where approximately 120 whales have been observed depredating. Therefore, this year we began a pilot project providing fishermen with reports from other fishermen and positions of satellite tagged whales twice daily, hoping to curb the expansion of depredation through avoidance and prevent new whales that enter Chatham from associating vessels with food.

Seasonal Distribution and Foraging Behavior of Cook Inlet Beluga Whales

Robert Small
Alaska Department of Fish & Game, bob.small@alaska.gov
Manuel Castellote
NOAA Alaska Fisheries Science Center, manuel.castellote@noaa.gov
Jeff Mondragon
Alaska Department of Fish and Game, jeff.mondragon@alaska.gov
Justin Jenniges
Alaska Department of Fish and Game, justin.jenniges@alaska.gov
Chris Garner
U.S. Army, Joint Base Elmendorf Richardson, CHRISTOPHER.GARNER@ELMENDORF.AF.MIL
Shannon Atkinson
University of Alaska Fairbanks, shannon.atkinson@alaska.edu
Marc Lammers
Hawaii Institute of Marine Biology, lammers@hawaii.edu

The population abundance of beluga whales in Cook Inlet, Alaska, is ~300 and has decreased annually for the last ~15 years; the population was listed as endangered in 2008. Knowledge of the seasonal geographic distribution and foraging behavior of the population is very limited, and based on movements and dive behavior of 14 belugas fitted with satellite tags in 1998-2000. Using passive acoustic monitoring, we obtained information on beluga presence and foraging behavior in Cook Inlet during 2008-2013. We monitored both low frequency social signals and high frequency echolocation signals at 13 monitoring locations. Beluga presence was calculated as the percentage of hours monitored during which belugas were detected. We defined beluga foraging behavior as echolocation click trains with 2 ms between consecutive clicks, and calculated a foraging index as the ratio of minutes in which foraging behavior occurred to the number of hours in which belugas were detected. Both beluga presence and foraging index were summarized for summer (ice free) and winter. From a total of ~11,769 monitoring days, belugas were detected at 12 of 13 locations; there were no detections at the southern-most location. Beluga presence in summer was more than twice that of winter, with beluga distribution relatively concentrated in the upper inlet during summer compared to a broader distribution in the mid- and lower inlet during winter. Across years, we observed a relatively consistent location-specific monthly pattern in beluga detections. Foraging behavior was extremely limited in winter, and then increased in April followed by a major increase to a peak in May, stayed elevated in June-August, decreased in September and reached a minimum in October. On a broad spatial scale, across the two seasons, the foraging index was highest in the upper inlet during summer; foraging essentially did not occur in the lower inlet. Belugas were not present in the lower inlet during summer, and although they were present in winter, their presence was low when compared to the upper inlet. These results suggest that winter foraging behavior is widespread, yet rarely detected or occurs infrequently.

Where Science Meets Policy: Protected Species Permitting and Take Estimation

Sarah Courbis
Smultea Environmental Sciences, LLC, sarah.courbis@smulteasciences.com
Mari Smultea
Smultea Environmental Sciences, LLC, mari@smulteasciences.com
David Steckler
Entiat River Enterprises, dave@smulteasciences.com

U.S. laws (e.g., Marine Mammal Protection Act, Endangered Species Act) require that science-based impact assessment and permitting occur as part of processes to conduct energy-related and other development/operational activities (e.g., seismic and navigation surveys, drilling) that may incidentally impact ("harass") marine mammals via underwater sound. In Alaska 2014-2015, 12 applications were submitted by eight companies to incidentally harass marine mammals via underwater noise associated with seismic surveys and drilling in Cook Inlet and the Chukchi/Beaufort seas. Permitting and its concomitant mitigation, monitoring, and reporting are a complex interaction among multiple laws and agencies. Further, permitting requires estimating the number of animals that may be harassed, a complex process fraught with ambiguity and much debate. To improve understanding of the permitting process, we provide flowcharts and other visual aids, briefly discussing future policy directions. This is important to permit applicants in terms of knowing what to expect and to scientists in terms of understanding (1) how laws and policy apply science, (2) what science is needed to inform permits and policy, and (3) how to substantively evaluate and comment on permit applications. To improve sound exposure estimates and enhance credibility of permitting processes, evaluation of limitations and assumptions underlying take estimation is needed. Currently, take estimation processes are inconsistently applied across projects, leading to marked variability in estimates. We aim to illuminate assumptions and limitations and provide some avenues to improve take estimation. In general, there is a lack of empirical testing of take models, and nearly all models are weakened by sparse data sets. Estimates are also usually designed to be extremely conservative. This is in part because of an inability to account for real-world variables, such as true seasonal/regional densities and mitigation effects. A disconnect between estimated and actual exposures is demonstrated by monitoring reports estimating actual take after project completion. We describe ways to improve existing processes that include (1) refining estimates based on data collected while projects are underway, (2) better data sharing and management (including data publication), (3) increased collaborative efforts, and (4) improved mitigation and monitoring approaches, including new technologies.

Filling in the Blanks: Multidisciplinary Approaches for Addressing Critical Data Gaps in our Understanding of the Structure of Southeast Alaska Harbor Porpoise (*Phocoena phocoena*).

Kim Parsons
NOAA Alaska Fisheries Science Center, kim.parsons@noaa.gov
Marilyn Dahlheim
NOAA Alaska Fisheries Science Center, Marilyn.dahlheim@noaa.gov
Manuel Castellote
NOAA Alaska Fisheries Science Center, manuel.castellote@noaa.gov

Harbor porpoise (*Phocoena phocoena*) are distributed throughout Alaska waters commonly inhabiting waters less than 100 m deep. This preference for shallower waters makes them highly vulnerable to incidental fisheries bycatch. The nature and magnitude of incidental takes are currently unknown but may be significant in some Alaska salmon (*Oncorhynchus* spp.) and Pacific herring (*Clupea pallasi*) fisheries. Line-transect abundance estimates obtained from the inland waters of Southeast Alaska suggest an overall decline in porpoise abundance in the mid- 1990s. Contrasting trends in abundance between the northern and southern regions suggest population structuring within the currently recognized southeast Alaska stock. Of utmost concern is that incidental takes could severely affect undefined localized stocks of harbor porpoise unless stock structure is identified. Population genetic analyses are currently underway, however sample sizes are severely limited in some key areas. Emerging technologies combined with ongoing ship surveys are currently being used to gain insight into the contemporary population structure and seasonal distribution of harbor porpoise in Southeast Alaska. We have adopted a multifaceted approach to maximize the data available from multiple different sources to address questions related to population trends and movements of harbor porpoise in the inland waters. Vessel surveys conducted in 2015 focused on regions where porpoise were locally abundant to maximize opportunities for acoustic and genetic sampling. Echolocation loggers (C-PODs) were deployed to collect acoustic data to characterize inter-specific differences within the family Phocoenidae. To maximize sampling potential for population genetic analyses, we developed and tested a modified tissue biopsy system in addition to conducting a pilot study to examine the utility of water sampling as a source of eDNA (environmental DNA) for detecting and characterizing genetic diversity in harbor porpoise. We present a summary of our efforts to gain insight into the structure of this species within the inland waters of Southeast Alaska, discuss the outcomes of these multidisciplinary approaches, and identify future avenues to address management concerns for this small and cryptic cetacean.

Managing the Invasive Tunicate, *Didemnum vexillum*, in Alaska

Ian Davidson
Smithsonian Environmental Research Center, davidsoni@si.edu
Tammy Davis
Alaska Department of Fish & Game, tammy.davis@alaska.gov

The old adage that "an ounce of prevention is worth a pound of cure" is a guiding principle in environmental management. Unfortunately, cures are often required when preventive barriers have been breached, but in the case of marine invasive species, prescribed cures are lacking. There is neither a long history of control and eradication attempts, nor detailed frameworks or guidelines, for species that invade marine habitats. Therefore, managing an 'outbreak' in the sea must take guidance from (a) an established theoretical literature, based mainly on terrestrial examples, (b) an emerging marine one, and (c) experimentation.

Since its discovery during a citizen-science marine invasive species bioblitz in 2010, the colonial tunicate, *Didemnum vexillum*, has been closely monitored in Whiting Harbor, Sitka. The species has a history of invasion around the world, with the potential to disrupt benthic communities and impact fisheries. To prevent its spread beyond its current known, and limited, Alaskan range, we have taken repeated measures of its distribution, removed infested floating infrastructure from the site, promoted limited access to the site by boats, and evaluated methods to kill the organism on the seafloor. Our factorial experiments to treat *D. vexillum in situ* with biocides (salt, chlorine, cement dust) induced 100% mortality in a subset of test plots. Chlorine and salt caused mortality on relatively uniform benthic habitat but were marginally effective on more complex boulder habitat. Continued monitoring and testing are being planned, especially related to increasing the spatial scale of treatments and overcoming the challenges posed by complex habitats.

As the pathways toward a 'cure' are developed for this invasion, there is an opportunity for marine resource management in Alaska to reduce the hazard of this species in the State, create a framework for future benthic invaders that may arrive, and inform marine invasion management elsewhere.

Graying of the Fleet in Kodiak's Fisheries: Defining the Problem and Assessing Solutions

Courtney Carothers
University of Alaska Fairbanks, clcarothers@alaska.edu
Rachel Donkersloot
Alaska Marine Conservation Council, rachel@akmarine.org
Danielle Ringer
University of Alaska Fairbanks, djringer@alaska.edu
Jesse Coleman
University of Alaska Fairbanks, jmcoleman@alaska.edu
Paula Cullenberg
Alaska Sea Grant, pjcullenberg@alaska.edu

The average age of state fishery permit holders in Alaska has increased by 10 years within the past few decades. Older people are retaining permits, and far fewer young people are becoming permit owners. In Kodiak's rural villages, for example, only 12 fishermen under the age of 40 hold fishing permits (representing an 84% decline of younger permit owners compared to the 1970s). Our 2015 survey of Kodiak middle and high school students reveals that less than 10% of students have ever worked in commercial fishing; and only 18% express interest in getting involved or more involved in fishing. We report here on findings from our ethnographic study of the dynamics creating this "graying of the fleet." Specifically we will report on our efforts to: 1) document and compare barriers to entry into, and upward mobility within, fisheries among youth and new fishery participants; 2) examine the factors influencing young people's attitudes towards, and level of participation in, Alaska fisheries; 3) identify models of successful pathways to establishing fishing careers among young residents; and 4) identify potential policy responses to address the graying of the fleet and develop specific recommendations consistent with state and federal legal frameworks. We also compare and contrast findings from Kodiak with our parallel study in the Bristol Bay region.

Examining the Effects of Herring Fishing Strategies on a Northeast Pacific Ecosystem

Szymon Surma
University of British Columbia, s.surma@fisheries.ubc.ca
Tony Pitcher
University of British Columbia, pitcher.t@gmail.com

Pacific herring (*Clupea pallasii*) is one of the most important Alaskan forage fishes, channeling energy from zooplankton to higher predators. These include protected seabirds and marine mammals as well as commercial fishes. Furthermore, herring supports numerous Alaskan communities via commercial, subsistence and aboriginal fisheries. In view of the recent poor status of many Gulf of Alaska herring stocks, humpback whale recovery and calls for ecosystem-based forage fish management, there is a clear need to examine the effects of herring management strategy design on the structure of Alaskan food webs.

We investigated the ecological effects of herring management strategy design using ecosystem modeling in Ecopath with Ecosim (EwE). The study area included parts of Southeast Alaska and northern British Columbia. A mass-balance Ecopath model representing the current state of the local food web was constructed. Effects of harvest control rule (HCR) type (constant effort, step, hockey stick), biomass limit reference point (*Blim*) and target fishing mortality (*Ftarget*) for herring on the biomasses of all model functional groups were examined using management strategy evaluation in EwE. Time series representing simulated variability in primary productivity and projected whale population recovery were used to evaluate top-down and bottom-up effects on simulation results.

Our results show that current herring management strategies, as well as some more precautionary ones, may have significant negative effects on the biomasses of humpback whales, transient killer whales, small odontocetes and harbor seals. Significant positive effects on pollock as well as blue and sei whales were also noticed. These biomass changes resulted from reduced prey availability for mammalian herring predators and competition for krill between herring, pollock and some baleen whales, with consequent bottom-up effects on transient killer whales. In general, these effects were more pronounced for lower *Blim* and higher *Ftarget* values, as well as step or constant-effort HCRs, although these differences were not always significant. Stock assessment error and poor primary productivity occasionally combined to cause notable negative effects throughout the food web. Effects of spawn-on-kelp fisheries alone were not significantly different from those of herring fishery closure. These findings illustrate the potential complexity of ecosystem-based herring fisheries management.

The Effects of Rising Sea Surface Temperature and Decreasing Salinity on Kelp Forest Ecosystems

Alyssa Lind
University of Alaska Fairbanks, aclind@alaska.edu
Brenda Konar
University of Alaska Fairbanks, bhkonar@alaska.edu

Kelp forests provide a multitude of vital ecosystems services, such as habitat for commercially and recreationally important species, support of complex food webs, and reduction of coastal erosion. The diversity and resilience of kelp forest communities are threatened as the severity of climate change and other anthropogenic stressors continues to mount. Particularly in Alaska, sea surface temperature (SST) is warming and glaciers are melting into coastal waters causing decreases in salinity. This study assesses the possible impacts of rising SST and decreasing salinity on coastal kelp forests in a North Pacific estuary, using Kachemak Bay as a model system. This two-part project combines both 1) a retrospective analysis of existing community and environmental data from kelp forests in Kachemak Bay, and 2) a factorial laboratory experiment investigating the effects of rising SST and decreasing salinity on kelp spore settlement and initial gametophyte growth. Rising SST and decreasing salinity were determined to negatively impact kelps and their associated communities to varying species-specific degrees. Results indicate that, while the gametophytes of all kelp study species experienced decreased germ tube growth rates at elevated temperatures and decreased salinities, *Eualaria fistulosa* was the most negatively impacted. The more widely distributed study species, *Nereocystis luetkeana* and *Saccharina* spp., were less negatively impacted during initial settlement and growth phases under the same conditions and are consequently likely to outcompete *E. fistulosa* under projected conditions. Using a multidisciplinary approach that combines ecological, physiological, and oceanographic perspectives, this research enhances our understanding of how kelp forests will respond to projected changes in SST and salinity, and provides insight to aid in the design of effective management strategies for North Pacific kelp forest ecosystems.

Gulf Watch Alaska in Hot Water! Ecological Patterns in the Northern Gulf of Alaska Under the Pacific 2014-2015 Warm Anomaly

Tammy Hoem Neher
NOAA National Ocean Service, tammy.neher@noaa.gov
Kris Holderied
NOAA National Ocean Service, kris.holderied@noaa.gov
Molly McCammon
Alaska Ocean Observing System (AOOS), mmcammon@aoos.org
Katrina Hoffman
Prince William Sound Science Center, khoffman@pwssc.org
Tom Weingartner
University of Alaska Fairbanks, tjweingartner@alaska.edu
Russ Hopcroft
University of Alaska Fairbanks, rrhopcroft@alaska.edu
Mandy Lindeberg
NOAA Alaska Fisheries Science Center, mandy.lindeberg@noaa.gov
Brenda Ballachey
U.S. Geological Survey, Alaska Science Center, bbalachey@usgs.gov
Daniel Esler
U.S. Geological Survey, Alaska Science Center, desler@usgs.gov
Heather Coletti
National Park Service, heather_coletti@nps.gov

Gulf Watch Alaska is the long-term, ecosystem monitoring program of the *Exxon Valdez* Oil Spill Trustee Council and is currently in its fourth of the first five year funding cycle of the program. This program integrates efforts of numerous field monitoring projects within the northern Gulf of Alaska region from Prince William Sound to Katmai National Park and Preserve. In the nearly three decades since the oil spill, researchers have been monitoring impacts to human communities and natural resources. These long-term data sets also are valuable for identifying potential drivers of ecosystem change in the context of a changing climate or other potential perturbations. Several data sets within the program extend across decades, through cool and warm water regimes, and are being used to focus process studies. In this presentation, we review observations from several of the monitoring projects during the 2014-2015 Pacific warm anomaly event, including warming waters, unusual plankton community compositions and bloom timing, higher marine mammal and seabird mortalities, increased harmful algal bloom events, and changing animal behavior patterns.

Gulf of Alaska Project: The Gauntlet Games - Final Showdown

Russell Hopcroft
University of Alaska Fairbanks, rrhopcroft@alaska.edu
Carol Ladd
NOAA Pacific Marine Environmental Laboratory, Carol.Ladd@noaa.gov
Franz Mueter
University of Alaska Anchorage, fmueter@alaska.edu
Olav Ormseth
NOAA Alaska Fisheries Science Center, Olav.Ormseth@noaa.gov
Kalei Shotwell
NOAA Alaska Region, kalei.shotwell@noaa.gov

The overarching hypothesis of the GOA Project has been that early life survival is the primary determinant of year-class strength or recruitment for marine groundfishes. This life stage is regulated in space and time by climate-driven variability in a biophysical gauntlet from offshore spawning regions to nearshore settlement. To test this hypothesis, the GOA Project concentrated on five commercially and ecologically valuable groundfish species that represent different life history strategies in the GOA. We conducted research on the different aspects of the gauntlet such as transport, the physical and chemical environment, planktonic prey fields and settlement habitat to determine the exposure profiles of each species and gain a better understanding of what influences survival. In this overview, we showcase the various stages of the gauntlet and provide examples of the differences between the five focal species. Field sampling and laboratory analysis provided information on the species distribution, energy, diet, and predators from the offshore to nearshore regions. Individual based modeling and habitat suitability analysis generated results on offshore to nearshore connectivity and settlement availability. Retrospective pattern analysis of historical time series identified primary modes of regional variability in the GOA and a clear east-west spatial breakpoint. This information combined with species-specific results from the field, laboratory, and modeling analyses were used to construct baseline conceptual models of the species life history and identify proxy indicators that influence recruitment. Fisheries stock assessment scientists and managers may utilize these baseline models and indicators to more efficiently manage the resource and develop more informed predictions of future stock status.

Poster Abstracts

WAVE 1

Monday, January 25
6:00 pm – 7:15 pm

Arctic - Climate and Oceanography

The Circulation Structure Around Hanna Shoal on the Northeastern Chukchi Sea Shelf

Ying-Chih Fang, Thomas Weingartner, Rachel Potter, Chase Stoudt, Elizabeth Dobbins

Presenter: Ying-Chih Fang

Email: yfang2@alaska.edu

Year-round moorings were deployed across the 40, 50, and 56 m isobaths northwest and northeast of Hanna Shoal to investigate circulation patterns and flow structure from September 2012 through September 2014. The results indicate a mean clockwise circulation of deep (>30 m) waters at depth, which was more apparent in the first year of deployment. Near surface currents were westward at ~4 cm s^{-1} on average at all moorings. Bottom currents (6 m above bottom) were eastward at ~5 cm s^{-1} northwest of Hanna Shoal and northeast of the shoal there was a weak westward flow, ~1 cm s^{-1}. The measurements suggest zonal exchange with cold, fresh surface waters and ice transported westward and cold, dense bottom waters transported eastward. On the northeast side of Hanna Shoal, this exchange results in strong, year-round stratification, with the pycnocline at ~25m depth. The persistent stratification and sea ice affects the vertical structure of the circulation.

Arctic - Climate and Oceanography

Interannual Variability of Barrow Canyon Transport

Chase Stoudt, Thomas Weingartner, Seth Danielson, Peter Winsor, Hank Statscewich

Presenter: Chase Stoudt

Email: castoudt@alaska.edu

Barrow Canyon is a major point of water exchange between the Chukchi Sea shelf and Arctic Ocean. There have never, however, been any long-term measurements to determine the mean and interannual variability in this transport. To achieve this goal we deployed an array of six moorings containing upward-looking ADCPs across the head of Barrow Canyon for two years (2010 – 2012). Moorings were spaced at 13 km intervals and thus provided the most accurate estimates of volume transport through the canyon to date. The along-canyon transport was largely confined to within 30-40 km of the coast consistent with the location of the Alaska Coastal Current (ACC). The mean transport over was ~0.2 Sverdrups (Sv) downcanyon (northeastward). Short-term transport variability can be huge with fluctuations ranging from 1.8 Sv downcanyon to 2.8 Sv upcanyon. Transport variability can alter between ± 1 Sv in a matter of days. Most of the transport variability is associated with local wind stress variations, but a significant source of the variability is caused by northward-propagating continental shelf waves forced by winds over the Bering Sea shelf. The first two years of measurements showed that a single mooring can reliably estimate transports through the canyon. We adopted this proxy sampling approach from 2012 – 2015 to form a 5-year time series of transport from Barrow Canyon. We use this time series to determine the long-term mean transport and to better quantify interannual transport variability and its sources.

Aspects of the Surface Circulation of the Chukchi Sea: A Lagrangian Perspective

Cayman Irvine, Tom Weingartner, Leandra Sousa, Peter Winsor, Elizabeth Dobbins, Seth Danielson

Presenter: Cayman Irvine

Email: cayman.irvine@gmail.com

Six clusters of CODE-type (1-m drogue) satellite-tracked drifters were deployed at both nearshore (< 20 km from the coast) and offshore (> 100 km seaward from the coast) locations in the northeastern Chukchi Sea in August and September of 2013 and 2014. Each cluster contained 12 – 26 drifters. Northeasterly (coastal-upwelling favorable) winds prevailed at the time of each deployment. The results indicate the potential for very large westward displacements of near surface waters, including the transport of warm, fresh Alaskan Coastal Water (ACW) westward from Pt. Hope across Hope Sea Valley into Herald Valley and Long Strait. Similarly ACW was transported westward from the Alaskan coast near Pt. Lay into the Central Channel. Farther north, cold, dilute meltwaters from around Hanna Shoal were drifted westward across the Chukchi Sea shelf, entering, and then transiting Herald Valley from the north to the south. These observations suggest a multiplicity of lateral mixing processes that might substantially alter the water mass properties of the shelf. Concurrent hydrographic data and the clustered nature of the deployments allow exploring the circulation dynamics for some of the clusters. The Hanna Shoal drifter trajectories, occurring where the shelf contains a strong and shallow pycnocline, appear to be governed principally by the Stokes' drift and Ekman dynamics. In contrast, drifter trajectories deployed far to the south of Hanna Shoal and adjacent to the Alaskan coast, where the stratification is weaker, appear to be largely controlled by geostrophic and Ekman dynamics.

IceTrackers: Low Cost, Easily Deployable Drifters for Tracking Ice Motion

Jeremy Kasper, Andrew Mahoney, Peter Winsor

Presenter: Jeremy Kasper

Email: jlkasper@alaska.edu

Highly complex patterns of ice motion and deformation were captured by fifteen satellite-telemetered GPS buoys (IceTrackers) deployed near Barrow, Alaska, in spring 2015. Two pentagonal clusters of buoys were deployed on pack ice by helicopter in the Beaufort Sea between 20 and 80 km offshore. During deployment, ice motion in the study region was effectively zero, but two days later the buoys captured a rapid transport event in which multiyear ice from the Beaufort Sea was flushed into the Chukchi Sea. During this event, westward ice motion began in the Chukchi Sea and propagated eastward. This created new openings in the ice and led to rapid elongation of the clusters as the westernmost buoys accelerated away from their neighbors to the east. The buoys tracked ice velocities of over 1.5 ms^{-1}, with fastest motion occurring closest to the coast indicating strong current shear. Three days later, ice motion reversed and the two clusters became intermingled. The data show no detectable difference in velocity between first year and multiyear ice floes, but Lagrangian time series of SAR imagery centered on each buoy show that first year ice underwent significant small-scale deformation during the event.

The five remaining buoys were deployed by local residents on prominent ridges embedded in the landfast ice within 16 km of Barrow in order to track the fate of such features after they detached from the coast. Break-up of the landfast ice took place over a period of several days and, although the buoys each initially followed a similar eastward trajectory around Point Barrow into the Beaufort Sea, they rapidly dispersed over an area more than 50 km across. With rapid environmental and socio-economic change in the Arctic, understanding the complexity of nearshore ice motion is increasingly important for predicting future changes in the ice and the tracking ice-related hazards including contaminants entrained in ice. This work demonstrates the ability of low-cost easily-deployable IceTrackers to generate to generate data of both scientific and operational value.

Arctic - Climate and Oceanography

ANIMIDA III

Jeremy Kasper, John Trefry, Bodil Bluhm, Ken Dunton, Greg Durell, Dan Holiday, Mark Savoie, Susan Schonberg, Tim Whiteaker, Sheyna Wisdom

Presenter: Jeremy Kasper

Email: jlkasper@alaska.edu

The Arctic Nearshore Impact Monitoring in the Development Area (ANIMIDA) III program, funded and designed by the Bureau of Ocean Energy Management, builds on our knowledge base of the sources, transport and bioaccumulation of contaminants in the coastal Beaufort Sea in order to continue to characterize and monitor active Beaufort Sea lease areas. In order to determine the hydrographic, chemical, benthic community structure and food web of the area, comprehensive geochemical, biological and physical oceanographic sampling were undertaken during the summers of 2014 and 2015 as well as during spring 2015. Recent data are merged with past results (e.g., from previous ANIMIDA and cANIMIDA work as well as data from earlier Beaufort Sea Monitoring and Outer Continental Shelf Environmental Assessment Programs) to show very little or no contamination in the ANIMIDA study area. Further, consistent with observed differences in hydrography, benthic communities differed between nearshore, shelf and slope zones. Spring freshet sampling took place during the rapidly evolving 2015 breakup and captured the dynamics of the rapidly spreading under-ice plume due to the Colville River as well as particulate and dissolved trace metals carried by the plume. The 2015 field season of the ongoing ANIMIDA long term monitoring project also included the first collection of two new lines in the Distributed Biological Observatory network. These two ANIMIDA III collection lines represent the first expansions of the DBO monitoring network that will eventually result in the formation of a circumpolar long term monitoring effort to understand ecosystem change due to climate change in polar Arctic regions. Data synthesis will be undertaken in 2015-2016.

Sea Level Measurements along the Alaskan Chukchi and Beaufort Coasts

Stephen Okkonen

Presenter: Stephen Okkonen

Email: srokkonen@alaska.edu

Water level recorders were deployed in lagoons and protected waters at Pt. Hope, Pt. Lay, Wainwright, Barrow, and Kaktovik during summer 2014 by local residents using local boats. Recovery is scheduled for fall 2015. The goals of this project are to use these local sea level measurements, along with those acquired by NOAA gauges at Red Dog and Prudhoe Bay, to

1) Improve understanding of ocean circulation and improve computer models of ocean circulation in the Chukchi and Beaufort Seas;

2) Investigate relationships between landfast ice breakout events and sea level changes;

3) Assess the effects of sea level changes on coastal erosion; and

4) Obtain data necessary for coastal protection and engineering design issues.

Preliminary analyses of sea level data will be presented.

Developing Oceanographic Infrastructure Specifically for the US Arctic

Heather Tabisola, Jessica Cross, Christian Meinig, Calvin Mordy

Presenter: Heather Tabisola

Email: heather.tabisola@noaa.gov

In a region where ice rules, monitoring ecosystem change as it occurs is a challenge. Traditional ship, satellite and mooring based data collection techniques are the backbone of oceanographic research. However, in this new frontier, autonomous vehicles and novel sensors are being developed to supplement traditional observation infrastructures. Growing interest in conducting such challenging US Arctic research led NOAA's Pacific Marine Environmental Lab (PMEL) to establish a collaborative science and engineering program, Innovative Technology for Arctic Exploration (ITAE) to design instrumentation specific to the big, remote, and harsh region. The mission of the ITAE program is to conceptualize and build effective research equipment for the assessment of the Arctic environment and ecosystem with the operation of high-resolution sensors on autonomous platforms. In the summer of 2015, ITAE program tested new technologies to supplement traditional ship, satellite and mooring based data collection techniques. During the program's first field testing year, ITAE successfully completed two large-scale research missions in the Bering and Chukchi Seas involving multiple new Arctic-capable platforms, including the Saildrone, an unmanned autonomous surface vehicle (Saildrone, Inc.), the Profiling Crawler (PRAWLER; NOAA-PMEL), a moored instrument drastically improving vertical resolution of data collection; and the Expendable Ice Tracking (EXIT) Float, which allow for under-ice data collection (NOAA-PMEL). Here, we provide an overview of the technologies used in the 2015 field season of the ITAE program.

Oil in Ice: Evolution of Pore Space Geometry Preferentially Occupied by Crude Oil

Marc Oggier, Kyle Dilliplaine, Hajo Eicken, Eric Collins, Bodil Bluhm, Rolf Gradinger

Presenter: Marc Oggier

Email: moggier@alaska.edu

Receding Arctic perennial sea ice and the suspected presence of substantial oil and gas reserves in the Arctic are likely to drive an increase of oil extraction and transport throughout the maritime Arctic. In the past decade, traffic through the Bering Strait has more than doubled and is expected to grow in the following years. Despite a decrease in sea ice extent, Arctic waters are covered with sea ice, which remains a major hazard for commercial activities most of the year. Sea ice is a key factor with respect to a potential oil spill in Alaskan waters, as it can trap substantial amounts of oil in the event of a blowout. At the same time, it serves as an important habitat for microbial communities and supports the Arctic food web. Porosity and microstructure evolution in sea ice is dominated by the combination of ice temperature and bulk salinity. During warming events the brine volume fraction tends to increase and pores interconnect, leading to a higher permeability.

In this study, we examine the linkages between sea ice pore microstructure and the oil entrapped in ice and potential impacts on ice biota. Artificial sea ice inoculated with biota is grown in indoor experiments at UAF prior to release of oil below ice. Ice is sampled before and after the oil release to characterize physical properties (salinity, oil distribution) and biological indicators (exopolymeric substance, biomass). Oil migration data are supplemented with observation provided by a large scale oil in ice experiment conducted at Cold Region Research and Engineering Laboratory in New-Hampshire. Microstructure and oil/brine volume fraction are characterized with X-ray tomography and thin/thick section micrography.

Oil migration in ice is highly related to the amount of oil present. Below a certain threshold, oil is encapsulated in the skeletal layer. If larger volumes are available, oil penetrates the main brine channel system and could surface through large brine channels. Later, during warm event, it migrates along the grain boundaries of ice crystals. Results support the development of an oil migration model, which may serve as a tool to improve oil spill response.

Seasonal Arctic Sea Ice Predictability Seen from CFSv2

Muyin Wang, Qiong Yang, James Overland

Presenter: Muyin Wang

Email: muyin.wang@noaa.gov

The rapid reductions in Arctic sea ice have been observed in the past several decades, especially, at the end of the summer melt season in September. This has serious impact not only on the surrounding environment, but also on the components of the ecosystems. It is therefore urgently needed to have a reliable seasonal forecast of Arctic sea ice conditions. In this study, we examined the Arctic sea ice predictions produced by NCEP Climate Forecast System version 2 (CFSv2) in the real-time operational mode. Forecasts were initialized monthly for four-year period (January 2012 to September 2015). Forecasts of sea ice extent (SIE), concentration (SIC), and sea ice thickness were examined against the Hadley Center sea ice analysis (HadISST_ice). Initial results showed that the Arctic September SIE forecasts from CFS were overestimated with the biases in SIC mainly originated from the Beaufort Sea, Laptev Sea and Fram Strait. We also found that when the forecast lead time of 6 months, i.e. initialized in March gave the best September SIE forecast while the forecast initialized from July with the lead-time of 2 months had the worst September SIE forecast. In order to understand these forecast biases, the atmospheric forcing fields including incoming solar/Infrared radiation, upward solar/infrared radiation from surface, latent and sensible heat flux, 2-meter air temperature, sea level pressure and 10-meter wind from the same CSFv2 were evaluated against the European Center for Medium-Range Weather Forecasts Interim Re-Analysis (ERA-Interim).

Arctic - Climate and Oceanography

Using Existing Laws to Address Key Threats to Alaska Marine Species

Miyoko Sakashita

Presenter: Miyoko Sakashita

Email: miyoko@biologicaldiversity.org

Climate change will increase extinction risk for many Alaska species, underscoring the need for effective mitigation (greenhouse-gas-reducing) and adaptation (resilience-increasing) strategies. The U.S. Endangered Species Act provides tools for climate change mitigation and adaptation for listed species, particularly through its requirements for critical habitat designation, recovery plans, and federal consultation, but to what extent have those tools been applied? We examine the success and challenges of using these tools in Alaska to address climate change threats and in the extent to which critical habitat designation, recovery plans, and consultation analyze climate change threats and provide measures to reduce them. We will draw upon case studies including the polar bear, ringed seal, bearded seal, and walrus. We will also discuss how to leverage water pollution laws to address threats from ocean acidification.

CHAOZ in a Nutshell: Five Years of Work in Twelve Minutes

Catherine Berchok, Christopher Clark, Jessica Crance, Ellen Garland, Julie Mocklin, Sue Moore, Jeff Napp, Brenda Rone, Adam Spear, Phyllis Stabeno, Muyin Wang

Presenter: Catherine Berchok

Email: Catherine.Berchok@noaa.gov

The BOEM-funded Chukchi Sea Acoustics, Oceanography, and Zooplankton (CHAOZ) study ran from September 2009 through August 2015, with field seasons in 2010-2012. The main objective of this study was to document the distribution and relative abundance of marine mammals (including bowhead, gray, beluga, killer, minke, humpback, right, and sperm whales, bearded and ribbon seals, and walrus) in areas of potential seismic surveying and oil and gas production and to relate variability in animal occurrence to oceanographic, atmospheric, and sea ice conditions, indices of prey density, and anthropogenic activities. Two years of long-term biophysical measurements (temperature, salinity, currents (ADCP), ice keel depth, pressure, chlorophyll fluorescence, nitrate, oxygen, turbidity, and zooplankton volume backscatter (using ADCP and TAPS6-NG)) and passive acoustic recordings were collected at three mooring sites 40, 70, and 120 nm off Icy Cape, AK. In all three field seasons, sampling stations (CTD and Tucker sled tows) were run along lines off Icy Cape, Point Hope, Cape Lisburne, Point Lay, Wainwright, and Barrow Canyon. Continuous passive acoustic monitoring (via sonobuoys) was conducted 24/7 along the cruise track, and visual surveys were conducted during daylight hours using a three-person rotating team on big-eyes (25x) binoculars. These during-cruise measurements and observations served to ground truth/calibrate the long-term data records and provide finer scale sampling between the mooring sites. Simulations with the NCAR climate model were executed and analyzed, and a noise model was initiated. A near real-time passive acoustic auto-detection buoy was also deployed and successfully transmitted biological signals and noise level metrics. The results of this study are available as a final report to BOEM; this talk condenses the 600 page report into about a dozen key findings. A brief summary of each of these findings will be presented along with contact information and any associated publications.

Assessing the Robustness of Quantitative Fatty Acid Signature Analysis to Assumption Violations

Jeffrey Bromaghin, Suzanne Budge, Gregory Thiemann, Karyn Rode

Presenter: Jeffrey Bromaghin

Email: jbromaghin@usgs.gov

Knowledge of animal diets provides important insights into their life history and ecology, relationships among species in a community, and potential response to ecosystem change or perturbation. Quantitative fatty acid signature analysis (QFASA) has become a prominent method of estimating the diet of marine species. However, research into the statistical performance of QFASA estimators has been limited. One important characteristic of an estimator is its robustness to violations of model assumptions. The primary assumptions of QFASA are: (1) the prey library contains representatives of all prey types consumed, and (2) the calibration coefficients, which compensate for differential metabolism of individual fatty acids, are known without error. We investigated the bias of two QFASA diet estimators resulting from violations of those primary assumptions, using computer simulation and two prey libraries of differing complexity. The Aitchison estimator was most robust to errors in the calibration coefficients, while the Kullback-Leibler estimator was most robust to the consumption of prey without representation in the prey library. In most cases, investigators will have some capability to evaluate the adequacy of a prey library based on their knowledge of predator ecology and preferences for the prey types available to them. Conversely, because calibration coefficients are derived from feeding trials with captive animals and their values may be sensitive to consumer physiology and nutritional status, their applicability to free-ranging animals is difficult to establish. We therefore recommend that investigators first make any improvements to the prey library that seem warranted and then estimate predator diets using the Aitchison estimator, as it appears to minimize risk from violations of the assumption that is most difficult to verify.

Sedimentation Deposition Patterns on the Chukchi Shelf Using Radionuclide Inventories

Lee Cooper, Jacqueline Grebmeier

Presenter: Lee Cooper

Email: cooper@umces.edu

Sediment core collections and assays of the anthropogenic and natural radioisotopes, ^{137}Cs and ^{210}Pb, respectively, are providing long-term indications of sedimentation and current flow processes on the Chukchi and East Siberian seas continental shelf. This work, which has been integrated into interdisciplinary studies of the Chukchi Sea supported by both the US Bureau of Ocean Energy Management (COMIDA Hanna Shoal Project) and the National Oceanic and Atmospheric Administration (Russian-US Long Term Census of the Arctic, RUSALCA) includes studies of total radiocesium inventories, sedimentation rate determinations, where practical, and depths of maxima in radionuclide deposition. Shallow maxima in the activities of the anthropogenic radionuclide in sediment cores reflect areas with higher current flow (Barrow Canyon and Herald Canyon; 3-6 cm) or low sedimentation (Hanna Shoal; 1-3 cm). The first sedimentation studies from Long Strait are consistent with quiescent current conditions and steady recent sedimentation of clay particles. Elsewhere, higher and more deeply buried radionuclide inventories (> 2 mBq cm^{-2} at 15-17 cm depth) in the sediments correspond to areas of high particle deposition north of Bering Strait where bioturbation in productive sediments is also clearly an important influence. Radiocesium activities from bomb fallout dating to ~1964 are now present at low levels (<1 mBq cm^{-2}) at the sediment surface, but burial of the bomb era radionuclide in sediments is observed to >20 cm. Independent sedimentation rate measurements with the natural radionuclide ^{210}Pb are largely consistent with the radiocesium measurements.

Marine Arctic Ecosystem Study (MARES) - An Integrated Approach to the Dynamics and Monitoring of the Beaufort Sea

Francis Wiese, Rowenna Gryba, Brendan Kelly

Presenter: Francis Wiese

Email: francis.wiese@stantec.com

MARES is an integrated ecosystem research initiative coordinated and planned by the Bureau of Ocean Energy Management, the Office of Naval Research, the National Aeronautics and Space Administration, the U.S. Coast Guard, and Shell through the National Oceanographic Partnership Program. The overarching goal is to advance our knowledge of the structure and function of the Beaufort Sea marine ecosystem so as to link atmospheric and oceanic drivers to sea ice patterns and marine mammal distribution and availability to local subsistence communities. The study, funded in 2014, focuses on the marine ecosystem along the Beaufort Sea shelf from Barrow, Alaska to the Mackenzie River delta in Canada and is scheduled to include bio-physical moorings along the US-Canadian border, glider deployments packed with bio-physical sensors, tagging of whales and ice-associated seals with satellite CTD-Fluorometer tags, biophysical and chemical cruises including the measurement and characterization of hydrography, ice, nutrients, primary and secondary production, carbon budgets, benthic fauna, fish, as well as analysis of freshwater input and chemical loadings, and ecosystem modeling. This presentation will focus on preliminary results from the ice seal tagging that started in the summer of 2015 and describe some of the planning and possibilities for partnerships for the more comprehensive 2016 field season and beyond.

North-South Trends in Benthic Biomass, Use by Key Benthivores, and Associated Environmental Drivers in the Chukchi Sea

Jacqueline Grebmeier, Lee Cooper, Bodil Bluhm, Katrin Iken

Presenter: Jacqueline Grebmeier

Email: jgrebmei@umces.edu

The Chukchi Sea is an inflow shelf of the Arctic with shallow bathymetry (<100 m) that is influenced directly by the advection of high nutrient Pacific water into the system. The bathymetry of the southern region is relatively flat compared to the more complex bathymetry to the north that includes shoals and canyons. The southern Chukchi Sea has offshore foraging sites for both walrus and gray whales. By comparison, the northern Chukchi Sea has spatially distinct foraging areas, with walrus focusing around Hanna Shoal and gray whales in nearshore waters near Barrow, Alaska. Field sampling in the southern and western Chukchi Sea includes efforts undertaken through the Russian-American Long-term Census of the Arctic (RUSALCA) and Distributed Biological Observatory (DBO) programs in the 2000s to present, along with the newly initiated AMBON (Arctic Marine Biodiversity Observing Network) project for the Chukchi Sea. Results from these projects are increasing our understanding of benthic systems in the region in relation to physical hydrographic forcing. Overall, both the macrofaunal and epibenthic community compositions at time series sites in the southern Chukchi Sea have remained relatively constant over the last decade, although some benthic faunal sites are showing significant local declines in biomass since 2004. In the northern Chukchi Sea, the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA) efforts since 2009, along with recent sampling during AMBON and DBO, indicate a more moderate level of water column chlorophyll standing stock and export to the benthos, with the highest levels of pelagic-benthic coupling southeast of Hanna Shoal. However, unlike the more persistent levels of benthic biomass, sediment oxygen uptake and sediment chlorophyll a content in the southern Chukchi Sea, these same parameters do not always mimic overlying water column processes in the northern Chukchi Sea due to variable flow dynamics. This presentation will evaluate the north-south trends in benthic biomass, pelagic-benthic coupling, and variability in the patterns of prey use by upper trophic level benthivores in the Chukchi Sea.

Synthesis of Arctic Research (SOAR) – Physics to Marine Mammals in the Pacific Arctic, Phase II

Lisa Sheffield Guy, Sue Moore, Phyllis Stabeno

Presenter: Lisa Sheffield Guy

Email: lisa.guy@noaa.gov

The Synthesis of Arctic Research (SOAR) brings together a multidisciplinary group of Arctic scientists and Alaskan coastal community representatives to explore and integrate information from completed and ongoing marine research in the Pacific Arctic (www.arctic.noaa.gov/soar). SOAR was initiated in 2011 with funding from the Bureau of Ocean Energy Management (BOEM) to increase scientific understanding of the relationships among oceanographic conditions (physics, chemistry, sea ice), benthic organisms, lower trophic pelagic species (forage fish and zooplankton), and higher trophic species (i.e., seabirds, walrus, whales) in the Pacific Arctic. The first phase of the synthesis resulted in a special issue of *Progress in Oceanography* comprised of 17 papers (http://www.sciencedirect.com/science/journal/00796611/136). The second Phase of SOAR will build upon this initial synthesis with a second special issue in *Deep Sea Research II – Topical Studies in Oceanography*. This issue will be framed by the same three overarching themes: (1) The 'New State' of the Pacific Arctic sector: Observations and models of sea ice loss, effects on primary production and acoustic ecology (5 papers); (2) Responses of mid-level trophic species to the 'New State' of the Pacific Arctic: Benthic and pelagic invertebrates and forage fishes (4 papers); and (3) Responses of upper-trophic species to the 'New State' of the Pacific Arctic: Marine mammal and seabird distribution, relative abundance, and phenology (7 papers). A complete list of SOAR Phase II special issue papers and contributors is available online at: http://www.arctic.noaa.gov/soar/SOAR_projects_2.shtml.

Alaska Monitoring and Assessment Program 2015 National Petroleum Reserve – Alaska Estuary Survey: A Report on Field Accomplishments

Terri Lomax, Ian Hartwell, Max Hoberg, Doug Dasher

Presenter: Doug Dasher

Email: dhdasher@alaska.edu

In August 2015 the National Petroleum Reserve – Alaska Chukchi and Beaufort Sea estuaries were surveyed by the Alaska Monitoring and Assessment Program (AKMAP) as part of EPA's National Coastal Condition Assessment (NCCA). The AKMAP survey was a joint effort by the Alaska Department of Environmental Conservation, University of Alaska Fairbanks Institute of Marine Science and the National Oceanic and Atmospheric Administration. The survey uses a probabilistic sampling survey design to estimate the spatial extent of ecological condition based on stressors and indicators. Stressors, such as chemical contaminants and water quality parameters, and indicators, such as macroinvertebrate biodiversity, are used at each station to relate biological response, contaminant exposure and habitat condition. Uniform sampling methods and analytical procedures are followed to allow for nation-wide comparisons of condition. AKMAP NPR-A used four NCCA indices of condition – water quality, sediment quality, benthic community condition, and fish tissue contaminants. As expected weather and local conditions, such as compacted sediments or scarcity of biota, did not allow for a 100% completeness of all the planned sampling events. An 85% completeness was achieved for the water column and chemical sediment sampling. This poster discusses the survey sampling design methodology, parameters sampled, tasks completed and provides some preliminary data from the AKMAP 2015 NPR-A Estuary survey.

Physical Control of the Distributions of a Key Arctic Copepod in the Northeast Chukchi Sea

Stephen Elliott, Carin Ashjian, Zhixuan Feng, Benjamin Jones, Changsheng Chen, Yu Zhang

Presenter: Stephen Elliott

Email: stephenmelliott@gmail.com

The copepod *Calanus glacialis* serves as a key grazer, predator, and prey for upper trophic level predators such as fish and bowhead whales in the Chukchi Sea. The Chukchi Sea is highly advective and is dominated by barotropically driven northward flow modulated by wind driven currents that often reach the bottom boundary layer. The physics establish the connection potential between specific regions and define the distributions of plankton such as *C. glacialis*. Here we explore pathways of dispersal of *C. glacialis* in the Chukchi and Beaufort Seas. *C. glacialis* distributions were described over Hanna Shoal in August 2012 and 2013. These distributions serve as the starting point for an exploration of *C. glacialis* population sources and sinks using physical-biological modeling. The Finite Volume Community Ocean i-State Configuration Model was used to advect the distributions forward and backward in time. We found that Hanna Shoal can supply diapause competent *C. glacialis* to the Beaufort Slope and Chukchi Cap, may receive most juveniles from the broad slope between Hanna Shoal and Herald Canyon and has the potential to receive second year adults from as far as the Anadyr Gulf and as close as the broad slope between Hanna Shoal and Herald Canyon. These connection potentials were not sensitive to precise times and locations of release, but were sensitive to depth of release. Deeper particles often traveled further than shallow particles due to strong vertical shear in the shallow Chukchi. The 2013 sink region was shifted west relative to the 2012 region and the 2013 adult source region was shifted north relative to the 2012 region. These findings support the existence of two subpopulations of *C. glacialis* with limited connection; one that dominates the Bering and Chukchi Seas and one that dominates the Arctic Ocean.

Trophodynamics of the Hanna Shoal Ecosystem: Connecting Multiple End-members to a Rich Benthic Food Web

Nathan McTigue, Susan Schonberg, Susan Saupe, Ken Dunton

Presenter: Ken Dunton

Email: Ken.dunton@utexas.edu

The Hanna Shoal Ecosystem Study, an extension of the Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA), includes a component to construct trophic relationships and carbon flow through the food web of the shoal and nearby areas of the Chukchi Sea. We use a multi-disciplinary approach to provide a baseline characterization of the Chukchi Sea benthic ecosystem to provide a benchmark against which future changes, related either to climate or from oil and gas activities, could be measured. This component of the study relied on plankton tows, benthic grabs, and beam trawls to collect plankton, invertebrates, and microalgae from ice and water column in August 2012 and 2013 from the USCG Icebreaker *Healy.* Over 650 samples were analyzed for stable carbon and nitrogen isotopes, including phytoplankton, particulate organic matter (POM), sediment organic matter (SOM), ice algae, and 90 species of consumers. Phytoplankton in the study area had an average stable carbon isotopic value of -22.7‰, although that ranged from -25.5 to -21.6‰. The suspension feeding amphipod *Ampelisca macrocephala* (mean $\delta^{13}C$ = -23.8‰) and copepod *Calanus* spp. (mean $\delta^{13}C$ = -22.3‰) likely assimilate a high proportion of carbon from phytoplankton based on this evidence. SOM reflected phytoplankton ranging from -25.2 to -22.0‰. POM at some stations showed ^{13}C-enrichment with depth (e.g., $\delta^{13}C$ value was -22.3‰ at 5m, but -21.2‰ at 58m) that might be indicative of either degradation and subsequent ^{13}C-enrichment as POM sank or the resuspension of ^{13}C-enriched SOM in near-bottom waters. Regardless, the most ^{13}C-enriched values of POM, phytoplankton, or SOM did not clearly explain some $\delta^{13}C$ values of 2nd trophic level consumers like the deposit feeding bivalves *Ennucula tenuis* at -17.3‰ or *Macoma moesta* at -18.9‰. Ice algae ($\delta^{13}C$ = -18.8 to -21.4) and microbially-degraded carbon are considered as ^{13}C-enriched end-members for the Hanna Shoal food web. In this analysis, we applied source partitioning models, which incorporate variation stable isotope values in the assumed trophic enrichment factor, to determine the probability of food web end-member assimilation for each species across Hanna Shoal.

The AOOS Arctic Data Portal: Access to Arctic Data and Information, Old and New

Carol Janzen, Molly McCammon, Rob Bochenek, Will Koeppen, Holly Kent, Darcy Dugan

Presenter: Carol Janzen

Email: janzen@aoos.org

For more than 10 years, the Alaska Ocean Observing System (AOOS) has dedicated significant resources to making observational and numerical data available digitally, graphically and for download through the Ocean Data Explorer Portal on its signature website--www.aoos.org. The Arctic Portal was developed as a subset of the Ocean Data Explorer, dedicated solely to Arctic data resources. It allows the public access to a multitude of information, both current (real-time and recently collected) and historical, while providing the ability to display data through combined GIS layers and real-time sensor data streams. It is designed to help users find, access, and analyze data for planning, research, decision making and emergency response for the Arctic. The portal is equipped with a “Data Catalog” to identify available datasets, and an interface to view and overlay data layers on a map. The system includes thumbnail views of the geographic extent of each layer, the metadata, and links back to the data provider. This portal offers access to over 200 data layers. Recently, AOOS and the Bering Sea Sub-Network (BSSN) partnered to bring the first wave of subsistence harvest data into the AOOS data portal. New data sources are continually added as they become available. Without the AOOS Arctic Portal, access to the diverse pool of existing information in the Arctic would require a prior knowledge of what data assets are present and where to find them, followed by visits to numerous websites that may or may not have graphical interface tools or easy access for uploading information in a unified format. A description of the types of data available and a demonstration of the Arctic Portal capabilities will be presented.

Highlights from the Arctic Eis project: A Study in Contrasts

Franz Mueter, Jared Weems

Presenter: Franz Mueter

Email: fmueter@alaska.edu

The Arctic Ecosystem Integrated Survey (Arctic Eis) conducted broad-scale ecosystem surveys in the northern Bering Sea and Chukchi Sea during two years (2012 and 2013) that were characterized by stark contrasts in atmospheric and oceanographic conditions. Differences in the wind field limited the northward extent of Bering Sea summer water and Alaskan coastal water in 2013, with recent melt water and Chukchi Sea winter water occupying much of the NE Chukchi Sea that year. These differences were associated with contrasting nutrient levels and biological differences extending from phytoplankton through zooplankton and fish communities to seabirds. Here we review the major differences across trophic levels relative to water mass structure and discuss potential linkages between physical and upper trophic level differences. In addition, we present selected highlights from associated studies that focused on the biology of several key species, in particular Arctic cod (*Boregadus saida*), saffron cod (*Eleginus gracilis*), and snow crab (*Chionoecetes opilio*).

Trend in Pacific Walrus (*Odobenus rosmarus divergens*) Tusk Asymmetry, 1990−2014

James MacCracken

Presenter: James MacCracken

Email: james_maccracken@fws.gov

We used the basal circumference of Pacific walrus (*Odobenus rosmarus divergens*) tusks (upper canine teeth, n = 21,068 pairs) to estimate fluctuating asymmetry (FA1 index) from 1990−2014. The mean difference in circumference between paired tusks was -0.006(SE = 0.002) cm and approximately normally distributed. Measurement error was 0.6(0.02)%, similar between biologists and lay persons ($P = 0.83$), and $\leq$ 15% of FA1. Tusk FA1 was greatest in 1990 then declined by 56% ($P = 0.0001$) through 2014. Male and female trends differed ($P = 0.0001$) and male FA1 was 40% greater ($P = 0.0001$) and the rate of decline 28% steeper ($P = 0.3$) than females. A quartic polynomial model ($r^2 = 0.66$, $w_i = 0.685$) fit the trend for female data better than simpler forms, whereas a linear model ($r^2 = 0.55$, $w_i = 0.693$) was a better fit for male data. Walrus tusk FA1 reflected periods when the population was stressed due to food limitations and then recovered, and perhaps when females began to experience the loss of preferred sea ice habitat in summer and FA1 is an easily monitored indicator. More work is needed to confirm the link between FA1, individual fitness, and adaptive potential.

Bioenergetic Consequences of Changing Sea Ice Availability for Pacific Walruses

Mark Udevitz, Rebecca Taylor, Chadwick Jay, Anthony Fischbach, Shawn Noren

Presenter: Mark Udevitz

Email: mudevitz@usgs.gov

As the extent of summer sea ice in the Chukchi Sea has declined, Pacific walruses have been increasing their use of coastal haulouts and their access to preferred offshore feeding areas has been reduced. These climate-induced changes in distribution and behavior could ultimately affect the status of the Pacific walrus population. We developed a behavioral model to relate changes in broad-scale metrics of sea ice availability to walrus activity levels, and a bioenergetics model to relate those activity levels to energy requirements. We then linked these models to global climate model forecasts of future ice availability to estimate energy requirements for mid and late century time periods. Walruses spent more time active in the water than hauled out and resting when broad-scale metrics indicated reduced sea-ice availability. Global climate model forecasts (CMIP5 RCP8.5) indicate the Chukchi Sea will be essentially ice-free for an average of about five months per year by midcentury, and that this will increase to an average of about nine months per year by the end of the century. The resulting increases in energy requirements have implications for reproduction and survival that may ultimately affect the status of the Pacific walrus population.

10 Years of Bowhead Whale Blubber – A Retrospective Analysis of Body Condition and Contribution of Sea Ice Derived Fatty Acids to Bowhead Whale Prey

Lara Horstmann-Dehn, Raphaela Stimmelmayr, Matthew Wooller, Craig George

Presenter: Lara Horstmann-Dehn

Email: lara.horstmann@alaska.edu

Bowhead whales (*Balaena mysticetus*) are the largest animal occupying ice-covered waters in the Arctic; they are exceptionally long-lived and migrate between arctic and sub-arctic waters. Bowheads feed on small zooplankton prey, such as copepods and euphausiids, and rely on high prey densities to balance energy expense during filter feeding and energy gain. Changes in sea ice abundance are well known to affect primary productivity in the Arctic, and copepod biomass appears to be increasing as a result. Bowhead health and food availability in the Arctic ecosystem are inextricably linked. The bowhead population has recovered substantially since commercial whaling in the mid-19th century and may be approaching pre-exploitation numbers. Consequences of the increasing whale population to abundance and quality of their prey are poorly understood. We therefore characterized annual variability of bowhead fatty acid (FA) signatures and overall lipid stores, as well as their reliance on sympagic food webs to fill important knowledge gaps. We sampled full thickness blubber cores from adult, non-pregnant whales in 2004–2014. Only whales harvested in Barrow, AK during the fall Native subsistence hunt were included. We then extracted and transesterified lipids and quantified up to 65 FAs. In addition, we used compound specific stable isotope (SI) analysis to examine the carbon SI ratio of specific primary production FA (i.e., 20:5*n*3) to describe the relative importance of sympagic or pelagic primary production to bowheads. Our preliminary data show no significant difference in blubber %lipid among years ($p=0.58$), although mean %lipid in 2014 was higher than any other year (71.14% ± 9.96 in 2014 versus 62.68% ± 9.82 for 2004–2013 combined). This agrees with projected increases in available bowhead prey biomass and abundance during early sea ice retreat and higher sea surface temperatures. The copepod FA markers 20:1*n*9 and 22:1*n*11 as well as the primary production marker 20:5*n*3 were variable among years. Interestingly, 16:1*n*7 appeared to be associated with relatively lower blubber lipid content, and has been described as an important player in lipolysis, potentially making it a useful indicator of body condition in bowheads. Compound specific SI analyses are currently underway.

Tooth and Bone: Reconstructing 2,500 Years of Pacific Walrus Foraging using Stable Isotope and Trace Element Analysis

Casey Clark, Lara Horstmann, Nicole Misarti

Presenter: Casey Clark

Email: ctclark@alaska.edu

Recent declines in Arctic sea ice have led to concerns regarding the future health of ice-dependent animal populations. Pacific walruses (*Odobenus rosmarus divergens*) rely heavily on sea ice as a platform for giving birth, molting, and resting between foraging bouts, making this species particularly vulnerable to warming climates and reduced sea ice coverage. This study uses stable isotopes of carbon and nitrogen ($\delta^{13}C$ and $\delta^{15}N$) in walrus bones, as well as trace element analyses of walrus teeth, to investigate changes in diet and feeding location across three time periods (prehistoric, historic, and modern). Samples were obtained from walrus remains collected in association with archaeological digs, housed in museum collections, and from Native subsistence harvests in Alaska. Major climatic anomalies, including the Roman Warm (2200 – 1900 BP, calibrated years before present), the Medieval Warm (1100 – 800 BP), and the Little Ice Age (450 – 150 BP) are encompassed by the prehistoric samples, while historic and modern samples span ~100 years and a series of major regime shifts in the North Pacific and Bering Sea. Preliminary stable isotope values differed significantly among all three eras ($\delta^{13}C$: $P < 0.001$; $\delta^{15}N$: $P < 0.001$), and analyses of eight fine-scale time periods revealed significant changes in both $\delta^{13}C$ and $\delta^{15}N$ within the prehistoric and historic eras. Analysis of trace elements allows for differentiation among observed changes in stable isotope ratios caused by trophic shifts and those caused by geographic movements. We used an Agilent 7500ce Inductively Coupled Mass spectrometer to measure concentrations of barium, cadmium, cesium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, strontium, and zinc in walrus teeth. This study is first of its kind and provides novel insight into the impacts of climate change on walrus foraging.

Population-Specific Responses to Changing Summer and Fall Sea Ice Conditions by Beaufort and Chukchi Sea Beluga Whales

Donna Hauser, Kristin Laidre, Harry Stern, Robert Suydam, Pierre Richard

Presenter: Donna Hauser

Email: dhauser@uw.edu

The consequences of rapid ecosystem transformations in the Pacific Arctic are unclear for migratory marine species such as beluga whales (*Delphinapterus leucas*). During summer, the Eastern Chukchi Sea (ECS) and Eastern Beaufort Sea (BS) populations of belugas migrate northeast of Bering Strait to high latitudes historically covered with dense pack ice. Here, we examine responses to sea ice shifts using satellite telemetry data spanning two decades to assess changes in population-specific habitat use, diving behavior, and fall migration timing, which may be related to regional summer-fall sea ice changes. We matched beluga locations with satellite-derived sea ice concentrations to compare early (~1990s) and late (~2000s) tagging periods, which correspond to significant decreases in sea ice concentration in ECS and BS July-November home ranges and later fall freeze-up in the Beaufort and Chukchi seas. Results revealed that ECS whales were associated with lower ice concentrations (1990s mean = 30.1% ± 0.8 SE vs. 2000s mean = 15.3% ± 0.8 SE), farther from the ice edge (1990s mean = 146.9 km ± 4.3 SE vs. 2000s mean = 178.6 km ± 5.9 SE), and significantly more likely to be located in open water in the 2000s than 1990s. Dive rates and surface-oriented behavior (dives <1 min and <10 m) were also significantly lower for ECS whales in the 2000s while long duration (>20 min) dives and mean dive depth were significantly greater. Ice associations for BS whales, in contrast, were not significantly different between periods, with whales most frequently located in open water except in September when whales migrated along the ice edge. Between early and late periods, ECS belugas also shifted home ranges to correspond with later freeze-up, remaining farther north and east a month later in the 2000s. Similar shifts and correlations with freeze-up timing were not detected for BS belugas. Our results suggest that ECS belugas are more tightly linked to sea ice than BS belugas during summer-fall, which contributes to apparent changes in ECS habitat, behavior, and phenology between periods. Distinct population-specific responses will complicate predictions of how species may fare in a changing Arctic.

Physiological Constraints to Diving: Defining the Capacity of Belugas to Alter Foraging Behaviors in Response to Habitat Degradation

Shawn Noren, Robert Suydam

Presenter: Shawn Noren

Email: snoren@ucsc.edu

Measurements of the physiology that support breath-hold capacity provide insight into the sub-surface behaviors of cryptic marine mammals and enhance our understanding of their flexibility to alter foraging behaviors when faced with habitat perturbations. Belugas (*Delphinapterus leucas*) have been identified as being negatively impacted by disturbance and habitat degradation from oil and gas exploration. To characterize age-specific vulnerability to these perturbations, we investigated the ontogeny of the anaerobic (acid buffering capacity) and aerobic (myoglobin content) properties of their locomotor muscle (*longissimis dorsi*) which support breath-hold. Belugas are born with surprisingly high myoglobin levels (1.56±0.02 g per 100 g wet muscle mass, n=2) compared to other pinniped and cetacean neonates. Despite a lengthy 2-3 year nursing interval, which has been correlated with prolonged muscle maturation in other marine mammals, myoglobin levels increased by 452% within the first year postpartum, achieving adult levels (6.91±0.35 g per 100 g wet muscle mass; n=9). Buffering capacity was 48.88±0.69 slykes (n= 2) at birth, and adult levels (84.31±1.38 slykes, n=9) were also achieved by one year postpartum. Rapid maturation of diving physiology may be a prerequisite for polar habitation of marine mammals, whose young are faced with ephemeral breathing holes as they transit alongside their mothers in this icy environment. Nonetheless, small body size constrains the breath-hold limits of immature belugas, which could make juveniles and females accompanied by calves especially vulnerable to habitat perturbations. This is the first investigation of the ontogeny of diving physiology and performance in a year-round Arctic dwelling cetacean.

Killer Whales Hunting for Walruses near the Village of Enmelen in August, 2006

Natalia Kryukova

Presenter: Natalia Kryukova

Email: sea-walrus@list.ru

Every year native of Chukchi Peninsula observes for killer whales (KW) hunt to walruses. Based on video materials we present description of KW hunting for walruses near village Enmelen (Anadyr Gulf, Bering Sea). The video has been shot at a height of 15 m by native Ettitegin Yu.I. The first hunting was in evening on the 2nd of August. KW surrounds a group of 14 walruses (including calf-of-the-year) firmly. Predators surfaced near walruses and hit them by fluke. As a result the KW abandoned them likely because the walruses were over the shallow. The second hunting was on the 5th of August. Small groups of walruses came to village area at night and stayed aswim there. There were about 1000 walruses over the shallow (200 m from the shore) in the morning. Aggregation of walruses lengthened out till 100 m. Majority of walruses were slipping and resting while some walruses were swimming. At a distance 100-200 m from walrus aggregation in the open sea 6 KW were swimming (including 2 males, without calves; it was group 1), which surfaced in the one place or having a little swam they came back without attacks to the walruses. The same situation lasted for 3-4 hours. Soon after another group of 12 KW (it was group 2) came from the Cape Bering (from South). They went abreast non-stop onto the walruses. At that time group 1 came to walruses from the opposite side. KW surrounded walruses (except shore side). The walruses were panic and gathering in dense group (its size became in twice less) intensively vocalization then they moved to the shore. After that the walruses swam over the shallow along the shore (at distance about 20 m from shore) to the Cape Chirickov. KW accompanied them moving at the distance of 100 m from them in the open sea without attacks. Lately at 5-7 km from village KW attacked the walruses with success (according to native). Thus once again our observations demonstrate active coordination between different KW groups at long distance and improbable congruence of their actions during hunting for walruses.

Quantifying Walrus Diet from Fecal Material Using Genomic Sequencing

Sarah Sonsthagen, Chadwick Jay, Robert Cornman, Anthony Fischbach, Sandra Talbot

Presenter: Sarah Sonsthagen

Email: ssonsthagen@usgs.gov

Pacific walruses forage on the seafloor for clams and other organisms, and haul out to rest on sea ice or land between foraging bouts. Reduction of summer sea ice in recent years has caused Pacific walruses to change their distribution in the Chukchi Sea. When sea ice retreats north past the edge of the shallow continental shelf, walruses must rest ashore and are displaced from historically preferred foraging areas. These new behaviors may affect the diet of walruses and their ability to meet annual energetic demands. To better understand the consequences of displacement from their preferred foraging areas on walrus energetics, body condition, and potentially survival and reproduction, we must understand what prey items are important to walruses and the availability and caloric contribution of those prey items to the walrus diet. Identifying and quantifying what walruses eat is difficult—all previous information on walrus diet has come from analyses of stomach contents of harvested animals. We developed a non-invasive, genomics approach to generate a dietary profile from walrus fecal matter collected from ice floes in the Chukchi Sea. From this we generated a comprehensive list of forage items ingested by walruses that included both primary prey and marine microbes, plankton, and meiofauna (e.g., diatoms). The taxonomic resolution of our marker sets was generally sufficient to identify taxa to family, with some high-confidence species-level assignments. Relative quantification of prey DNA is inherently problematic; nevertheless, we were able to infer dominant taxa in fecal matter. The majority of genomic data suggest that forage items belong to 8 classes of organisms (bivalves, tunicates, sea cucumbers, polychaetes, sipunculids, gastropods, sea anemones, and decopods), representing 3 orders and 5 families. Correlating these dietary profiles with the distribution of foraging areas and prey biomass may improve our ability to detect potential changes in the walrus diet in response to a changing Arctic ecosystem.

Hunter-Assisted Study on Ringed and Bearded Seal Movements, Habitat Use, and Traditional Knowledge

Mark Nelson, Lori Quakenbush, Merline Henry, Alexander Niksik, Albert Simon, John Goodwin, Alex Whiting, Kathy Frost, Justin Crawford

Presenter: Mark Nelson

Email: Mark.Nelson@Alaska.gov

Ringed (*Pusa hispida*) and bearded (*Erignathus barbatus*) seals depend on sea ice for pupping, nursing, molting, and resting. In Alaska, these seals are found in the Bering, Chukchi, and Beaufort seas and are important subsistence species used by Alaska Natives for food, oil, clothing, and handicrafts. Changes in the timing and extent of sea ice have increased access to the Arctic, increasing the need to plan shipping lanes, oil and gas lease sales, and develop mitigation measures to minimize effects on seals. Our understanding of important seal habitats and the timing and magnitude of movements by species, sex, and age, however, is limited. Expanding upon a cooperative satellite-tagging study with hunter-taggers and biologists in Kotzebue Sound that tagged more than 70 ringed and bearded seals, this study works with hunter-taggers from other regions in widely spaced villages to better understand range and timing of movements, relationship with sea ice, important habitats, and degree of seasonal site fidelity and minimize the effects of one tagging location. In 2014 and 2015, hunter-taggers from Kotzebue, Koyuk, St. Michael, and Hooper Bay captured, tagged, and released 12 bearded seals and six ringed seals. In 2014, four ringed seals and one bearded seal tagged in Kotzebue Sound spent the winter in Kotzebue Sound (2 ringed and 1 bearded) and Norton Sound (2 ringed). Two of three bearded seals tagged in Norton Sound in 2014 spent the winter there while one wintered in the Bering Sea. In 2015, three of eight bearded seals tagged in August in Norton Sound moved north into the Chukchi Sea, a fourth spent time due west in Mechigmenan Inlet (Russia), a fifth moved south to near St. Paul Island, and the remaining three stayed in Norton Sound. Local and traditional knowledge is also important to understand how seals respond to changing sea ice conditions. We met with hunter-taggers and other subsistence users in Barrow, Elim, St. Michael, and Stebbins to document historic seal behavior and recent changes. Future plans include training more hunter-taggers, and documenting more local and traditional knowledge to better understand how seals are responding to their changing environment.

Updated Status of Ringed and Bearded Seal Productivity in Alaska Using Harvest-Based Monitoring Results for 2013 and 2014

Lori Quakenbush, Justin Crawford, John Citta, Anna Bryan

Presenter: Lori Quakenbush

Email: lori.quakenbush@alaska.gov

Arctic sea ice has declined in extent, thickness, and duration; these declines are predicted to continue, along with a reduction in snow cover and an increase in winter rainfall. Declines in sea ice are predicted to negatively affect both ringed (*Pusa hispida*) and bearded (*Erignathus barbatus*) seals by reducing their time to rest, pup, nurse, and molt on sea ice. A reduction in snow cover and increasing rainfall is expected to be especially detrimental to ringed seal productivity and pup survival, because ringed seals are dependent upon snow cover for the construction of pupping dens. There are no reliable estimates of ringed and bearded seal abundance or trend in Alaska; however, since 1960, the Alaska Department of Fish and Game has worked with Alaska Native hunters to collect data from the subsistence harvest that can be used as an index to population health and status. We have previously published an examination of several population indices to determine if declines in sea ice have affected ringed and bearded seals between 1975 and 2012; these indices included sternal blubber thickness, growth rate, pregnancy rate, age of maturity, and the proportion of pups in the harvest. Pregnancy rates varied minimally since 1975 (ringed range: 78–85%, bearded range 94–96%); however, age of maturity was the youngest observed (average 3.9 years for ringed and 2.6 years for bearded seals) between 2003 and 2012. Additionally, pups were harvested in greater proportions during 2003–2012 than during 1975–1984 for ringed (51% and 15%) and bearded (51% and 26%) seals, indicating that pups were being produced, weaned, and surviving to be harvested. Through 2012, we observed no evidence of a decline in any population indices as predicted to occur with climate change. However, continued monitoring is important. Here we update our 1975–2012 results to include the 2013 and 2014 sample years.

Occurrence of Humpback, Fin, and Minke Whales in the Eastern Chukchi Sea, 2008-2015: Population Recovery, Response to Climate Change, or Greater Effort?

Janet Clarke, Megan Ferguson, Amelia Brower, Amy Willoughby, Christy Sims

Presenter: Janet Clarke

Email: janet.clarke@leidos.com

Sightings of humpback (*Megaptera novaeangliae*), fin (*Balaenoptera physalus*) and minke (*Balaenoptera acutorostrata*) whales were made during the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by BOEM and co-managed by BOEM and NOAA. Surveys were conducted in the eastern Chukchi Sea (67°-72°N, 157°-169°W) from July through October, 2008-2015, in a study area that encompassed offshore oil and gas leases in the Chukchi Sea Planning Area and shipping lanes in the southern Chukchi Sea. Approximately 172,000 km on effort was flown to document relative abundance, spatial and temporal distribution, and behavior of marine mammals. Fin whales (38 sightings of 63 whales) had the most limited distribution, from 67°N to 69.5°N, and were seen primarily in August and September. Humpback whales (49 sightings of 85 whales) were distributed from 66.9°N to 71.2°N, and were seen primarily in September. Minke whales (24 sightings of 27 whales) had the most extensive distribution, from 67.1°N to 71.9°N, and were seen from July through September. There were no sightings of these species in October. Fin, humpback, and minke whales were often seen in close association with other cetacean species, including gray whales. Behaviors observed included diving, feeding, milling, resting, rolling, swimming, and tail slapping. Fin whale calves (2) were seen in 2012; humpback whale calves were seen in 2014 (1) and 2015 (1). Fin, humpback and minke whales are known to have occurred historically in the Pacific Arctic, particularly near the Chukotka Peninsula, and recent visual and acoustic detections suggest that use of this area may be increasing. During aerial surveys conducted from 1979-1991 in this same area, there was 1 sighting of 3 fin whales; however, survey effort was sporadic among years, and most survey effort occurred in October. Increased occurrence may be due to each population's abundance and range recovering from commercial whaling that occurred as recently as the 1970s, but may also reflect an increase in marine mammal research in the area or responses to ongoing climate change.

Gray Whale Foraging Occurrence in the Northeastern Chukchi Sea, Summer and Fall 2015

Amelia Brower, Janet Clarke, Amy Willoughby, Megan Ferguson

Presenter: Amelia Brower

Email: amelia.brower@noaa.gov

Foraging gray whales were documented in the northeastern Chukchi Sea in summer and fall 2015 by the Aerial Surveys of Arctic Marine Mammals (ASAMM) project. ASAMM line transect surveys, conducted by the National Marine Mammal Laboratory and funded and co-managed by the Bureau of Ocean Energy Management, were conducted in the eastern Chukchi Sea, 67°-72°N and 155°-169°W, periodically from 1982 to 1991 and 2008, and consistently from July through October 2009-2015. In 2015, foraging gray whales sighted on transect effort in all months were documented predominantly between Point Barrow and Point Franklin 10-30 km from shore, and to the NNW of Wainwright 25-40 km from shore and 65-90 km from shore. Scattered foraging gray whale sightings were nearshore west of Icy Cape, north of Point Lay, in Ledyard Bay, and offshore ~100 km SW of Point Hope. Gray whales typically begin to arrive to the northeastern Chukchi Sea in June and July; they feed heavily in July and August, and migrate south in September and October. Beginning in August of previous years, ASAMM has documented gray whales foraging farther offshore; however, in 2015, gray whales were consistently sighted offshore in an area 65-90 km to the NNW of Wainwright earlier in the season, from July continuing into September. Gray whales were seldom seen in that area during July of previous years. Other differences in foraging distribution are that gray whales were documented foraging between Point Franklin and Icy Cape up to ~70 km offshore and foraging east of 157.8°W in some previous years; gray whales were seldom sighted foraging in these areas in 2015. These differences in distribution could be due to changes in prey distribution resulting from changing hydrographic conditions and oceanic productivity or from intense feeding by gray whales. The spatial and temporal changes in gray whale foraging distribution highlight the need for continued broad-scale aerial surveys each summer and fall, particularly as global climate change accelerates and multi-year sea ice continues to melt.

Gray Whale Calf Occurrence in the Northeastern Chukchi Sea, Summer and Fall 2015

Amy Willoughby, Amelia Brower, Janet Clarke, Megan Ferguson

Presenter: Amy Willoughby

Email: amy.willoughby@noaa.gov

Eighty-three Eastern North Pacific (ENP) gray whale (*Eschrichtius robustus*) calves were observed during systematic line transect aerial surveys conducted from July to September 2015 in the northeastern Chukchi Sea (67°-72°N, 169°-156°W). These surveys, part of the Aerial Surveys of Arctic Marine Mammals (ASAMM) project, funded by BOEM and co-managed by BOEM and NOAA, have been conducted from July to October since 2009 to document the relative abundance and distribution of marine mammals in the Chukchi Sea Planning Area. The Chukchi Sea is recognized as the northernmost extent of the gray whale's seasonal migration, and serves as important foraging and weaning grounds during summer and fall. Recent survey seasons have recorded an increase in gray whale calf occurrences. The gray whale calf ratio for 2015 (0.19; 83 calves, 438 total gray whales) was the second highest since 2009. Calf sighting rates (number of calves on effort per km flown) have also been high, particularly since 2012. Calf distribution in 2015 was similar to previous years, with the greatest number of sightings occurring nearshore along the Alaskan coast from Point Lay to Barrow, although >45% of gray whale calves sighted in 2015 were 25 to 85 km offshore NNW of Wainwright. While survey effort varies annually and repeat calf sightings are possible, our gray whale calf occurrence findings are consistent with the NMFS Southwest Fisheries Science Center's high counts of cow-calf pairs documented during their annual migration north along the California coast. Increases in calf occurrence could be due to favorable foraging conditions from 2011 to 2014 resulting in higher reproductive success. More gray whale cow-calf pairs may be migrating to the northeastern Chukchi Sea if there is reduced resource productivity in other cow-calf pair habitat or increased inter- or intraspecific competition on favored foraging grounds. On the contrary, high calf occurrences observed from 2012 to 2015 may be more typical than not, while findings of low calf occurrence from 2009 to 2011 may be uncharacteristic; future monitoring would be required to test this hypothesis.

Results from Hunter-Assisted Sampling of Pacific Walrus near Saint Lawrence Island, Alaska, 2012–2014

Anna Bryan, Lori Quakenbush, Jonathan Snyder, Harold Kiyuklook, Sheena Anningayou, Mark Nelson

Presenter: Anna Bryan

Email: anna.bryan@alaska.gov

Pacific walruses (*Odobenus rosmarus*) are harvested each spring for subsistence purposes by Alaska Natives near coastal villages in the Bering and Chukchi seas. Walruses live in remote, ice-covered waters and are extremely gregarious, hauling out on ice in huge congregations, which makes counting them extremely difficult. Without reliable estimates of population size or trend, data provided by sampling the harvest allows us to examine parameters that affect population health, which is of increasing importance due to rapid environmental changes to walrus habitat. Hunters sampled 204 walruses (96 females, 104 males, and 4 unknowns) during spring 2012–-2014 and classified the health of 187 of them; 97% of which were average or very good health. The average age (years) of sampled walruses was 14 for females and 20 for males. Contaminant concentrations (organochlorines and trace elements) for 42 walruses have been analyzed. Results are similar to or lower than concentrations found in Alaskan ice seals. For some marine mammals arsenic concentrations are known to be higher in blubber than other tissues commonly tested, although it is thought to be non-toxic. We found blubber concentrations (2.74 ppm) were higher than liver (0.27 ppm) and kidney (0.29 ppm). Blood (sera) from 151 walruses was screened for disease exposure (morbillivirus, brucella, herpes, leptospira, and toxoplasma); exposures were low except for herpes, which is common and expected. Stomach and intestinal contents were examined for prey, which included marine worms, clams, snails, crabs, shrimp, and fish. Intestinal contents were tested for domoic acid and saxitoxin produced by harmful algae blooms (HABs) known to concentrate in clams. HABs are predicted to increase in northern seas as water temperatures increase; we found higher than expected levels for both domoic acid (2–6,457 ng/g) and saxitoxin (6–1,162 ng/g). No walruses appeared to be symptomatic; however such concentrations of HABs have had negative effects on California sea lions (*Zalophus californianus*). Liver concentrations of vitamin E were similar for males and females, but males had significantly higher concentrations of vitamin A. Most of the adult females sampled were pregnant, which we attribute to availability and hunter selection bias.

Polar Bear (*Ursus maritimus*) Behavior near Icebreaker Operations in the Chukchi Sea, 1991

Mari A. Smultea, Jay Brueggeman, Frances Robertson, Dagmar Fertl, Cathy Bacon, Richard A. Rowlett, Gregory A. Green

Presenter: Mari A. Smultea

Email: mari@smulteasciences.com

Increasing interactions with anthropogenic activities, combined with impacts of climate change, are of critical concern for the conservation of polar bears (*Ursus maritimus*) in the U.S. Arctic and beyond. Our study quantified and described initial reactions and subsequent behaviors of polar bears within view of an icebreaker vessel. Observations of polar bear behavior near icebreaker operations occurred during summer 1991 at two exploratory drilling sites (near sites recently drilled in 2015) located in the Chukchi Sea 175 km and 312 km west of Barrow, Alaska. Polar bear behavior was described using continuous sampling of six pre-determined focal group behavior states (walk, run, swim, rest, feed/forage, unknown) and six reaction behavioral events (no reaction, walk away, run away, approach vigilance [i.e., watching], unknown). Forty-six bears in 34 groups were monitored from the *Robert LeMeur* (an Arctic Class 3 icebreaker) for periods of 5 minutes to 16.1 hours. Significantly more bear groups reacted to icebreaker presence than not (79% versus 21%, respectively), with behavioral reactions observed regardless of distance to, or activity of the icebreaker. Reactions were generally brief with “vigilance” the most common behavioral reaction, followed by “movement away”. Most reactions involving movement away from the icebreaker were short in both duration and distance. Eleven percent of bear groups approached the vessel. The presence of a cub had no significant effect on whether a bear reacted or not. Despite the limited sample sizes and elapsed time since data collection, these findings are currently relevant to assessing potential impacts of resource development and shipping activities on polar bears: climate change is leading to overall longer and more extensive open-water Arctic seasons, facilitating anticipated increases in vessel traffic numerically, temporally and spatially.

Abundance and Habitat Partitioning of Bowhead, Gray, and Beluga Whales near Barrow, Alaska, 2007-2011

Kim Shelden, Kimberly Goetz, Nancy Friday, David Rugh, Julie Mocklin, Linda VateBrattstrom

Presenter: Kim Shelden

Email: kim.shelden@noaa.gov

The Bowhead Whale Feeding Ecology Study conducted field operations from 2007 to 2011. Research focused on late summer oceanography and prey densities relative to bowhead (*Balaena mysticetes*) distribution over continental shelf waters near Barrow, Alaska. The aerial survey component provided information on the spatial distribution of bowheads as well as beluga (*Delphinapterus leucas*) and gray (*Eschrichtius robustus*) whales. Sighting numbers were variable from year to year for bowheads (mean=44, SD=36, range: 16-103) and belugas (mean=23, SD=41, range: 0-95), but fairly consistent for gray whales (mean=19, SD=8, range: 6-26). Habitat partitioning was evident among the cetacean species. The model included bathymetry, bathymetric slope, distance from shore, and distance from shelf break. Distance from shore and distance from the shelf break were significant in predicting the presence of bowheads ($p < 0.01$). All four parameters were significant in predicting gray whale presence ($p < 0.01$). Only bathymetry was significant in predicting beluga presence ($p < 0.01$). Although the regions occupied by these species overlapped, there was clear spatial separation in their preferred habitats. Bowhead habitat included continental shelf waters along the barrier islands and Barrow Canyon where it is closest to shore. Belugas preferred submarine canyon waters while gray whales preferred shallow water that was closer to shore and the shelf break.

Bering Strait Acoustic Monitoring Network: An Approach to Detect, Quantify and Minimize Impacts in the Arctic

Ricardo Antunes, Stephanie Sardelis, Leigh West, Martin Robards, Brandon Southall, Kate Stafford, Howard Rosenbaum

Presenter: Ricardo Antunes

Email: rantunes@wcs.org

Current changes in the Arctic due to rapid climate warming and expansion of anthropogenic activities, such as shipping and oil and gas exploration, pose a threat to this fragile ecosystem and the people who depend on it. To best understand and mitigate the impacts of these changes it is necessary to monitor ecosystem components over long time periods. Recent studies have called attention to data gaps and lack of baselines for marine mammal populations in the Arctic. Marine mammals are particularly susceptible to the increase in environmental noise generated by the growing anthropogenic activities in the region. The lack of baseline data on marine mammals precludes development of effective mitigation measures and impedes well-informed assessment of changes in this component of the ecosystem. The Bering Strait is a particularly sensitive area where the entire Endangered Bering-Chukchi-Beaufort bowhead whale population gathers for a few weeks during the spring and fall migrations. This is also the only route for ships between the Bering and Chukchi Seas, especially those servicing the increasing exploration of E&P and mining activities. Acoustic monitoring is an effective way to address data gaps, establish baselines, and understand the degree of natural and human-generated noise confronting marine mammals. During our NPRB funded project, we have and will analyze previously collected acoustic recordings. Additionally we are deploying new bottom mounted recording stations in the Bering Sea to monitor biological and anthropogenic activities over broad spatial/temporal scales. Preliminary analyses of an initial dataset between October 2014 and June 2015 off St. Lawrence Island resulted in bowhead, minke, beluga, and killer whales detections as well as walrus and bearded seals. Bowhead whale sounds dominated recordings during October-January, after which point walrus and bearded seal calls become prevalent. Work will continue for two years and the variability of detections will allow baseline assessment of the timing of migration and the relative use of different areas by various marine mammal species. The information provided by our project will provide the best available science to guide recommendations concerning the most appropriate management strategies for species and important habitats in the Bering Strait region.

Using Movement, Diving and Haul Out Behavior to Identify the Relative Importance of Foraging Areas for Walruses in the Alaskan Chukchi Sea

Justin Crawford, Lori Quakenbush, John Citta, Clarence Irrigoo Jr., Patrick Lemons

Presenter: Justin Crawford

Email: Justin.Crawford@alaska.gov

Female Pacific walruses and their young summer in the Chukchi Sea, resting on sea ice between benthic feeding bouts, when sea ice is available. The rapid decrease of sea ice in summer is changing walrus habitat in the Chukchi Sea and consequently the Pacific walrus is being considered for listing under the U.S. Endangered Species Act. Knowing the location and use of foraging areas is important as industrial and shipping activities increase. We worked with walrus hunters from Saint Lawrence Island to deploy 88 satellite-linked dive recorders on walruses in the Chukchi Sea during three multi-agency walrus research cruises in June of 2013–2015. Of the 88 tagged walruses, 79 were females (34 of which were accompanied by calves of the year and 45 were not) and 9 were adult males. Walruses were tracked for up to 124 days. Using data from 2013 and 2014, we identified Hanna Shoal, a known foraging area for walruses, and Icy Cape as two areas within the Alaskan Chukchi Sea with a higher than average density of dives. To evaluate the relative importance of these areas for foraging, we compared diving and haul out behavior within these two areas with that found in the rest of the Alaskan Chukchi Sea. Adult females (with and without calves) dove longer (6.2 *vs.* 4.5 min), made fewer dives (6.6 *vs.* 8.1 dives/hour), and hauled out for a larger proportion of time (22.1 *vs.* 17.0 min/hr) at Hanna Shoal than the other two areas ($P < 0.01$). Icy cape and the rest of the Alaskan Chukchi Sea did not differ statistically. Walruses in better quality habitat, with higher densities of prey, are expected to make fewer dives, dives of longer duration and spend more time resting. As such, diving and haul out behavior indicated higher quality habitat near Hanna Shoal than Icy Cape and the rest of the Alaskan Chukchi Sea, which were similar to each other. Therefore, Icy Cape may not be higher quality foraging habitat than the Alaskan Chukchi Sea in general. Here we update our 2013 and 2014 results to include data from 2015.

Polar Bears as a Sentinel for Emerging Wildlife Zoonoses: Past and Present Occurrence of *Brucella* spp., *Coxiella burnetii*, and *Toxoplasma gondii* in the Southern Beaufort Sea Population

Kelly Patyk, Colleen Duncan, Jack Rhyan, Pauline Nol, Matt McCollum, Todd Atwood

Presenter: Kelly Patyk

Email: kelly.a.patyk@aphis.usda.gov

Environmental changes, including dramatic declines in summer sea ice extent and duration, have been linked to adverse consequences for sea-ice obligate marine mammals such as polar bears (*Ursus maritimus*). Although primarily a marine predator, polar bears have had an increased presence on land in recent decades. The resulting changes in bear behavior, for example, scavenging on shore and aggregation at bowhead whale remain piles, may lead to greater opportunities for intra- and inter-species interactions and disease transmission. *Brucella* spp., *Coxiella burnetii*, and *Toxoplasma gondii* are contagious, zoonotic disease agents which have been identified in humans and wildlife, and have implications on public health and food safety, particularly in the Arctic where humans rely on a variety of wildlife species for subsistence. This study analyzed serum samples from southern Beaufort Sea polar bears to investigate exposures to these three pathogens. The seroprevalence of *Brucella* spp., *C. burnetii*, and *T. gondii* antibodies in polar bears captured 2007 – 2014, was determined. Results were interpreted in the context of individual bear behavior, when known, and compared to previous serosurveys done in this species. Further study of non-serum samples and an evaluation of risk factors for exposure are ongoing. As an apex predator, polar bears may be effective sentinels of change for the Arctic marine ecosystem, and monitoring prevalence in polar bears could provide insight into transmission risks for other species.

Progesterone Concentration and Ovarian Activity in Postpartum Pacific Walruses (*Odobenus rosmarus divergens*)

Jenell Larsen, Shannon Atkinson

Presenter: Jenell Larsen

Email: jtlarsen@alaska.edu

The US Fish and Wildlife Service has found sufficient evidence to list Pacific walruses *(Odobenus rosmarus divergens)* under the Endangered Species Act by 2017. The population status of Pacific walruses is uncertain, as are many of the life history traits of this species. Little is known about the reproductive physiology of walruses, specifically the endocrine parameters revolving around reproduction. A limited amount of research has measured progesterone concentration of captive, living, female Pacific walruses using vaginal smears and saliva. One recent study has also shown progesterone concentration can be measured in the bones of deceased, including archaeological, walruses. However, to date, progesterone concentration has never been measured from tissues of free-ranging Pacific walruses. Ten reproductive tracts of adult, female Pacific walruses were analyzed for progesterone concentration and ovarian activity. The animals were harvested in 2011 by Alaska Native hunters in the communities of Gambell and Savoonga on Saint Lawrence Island. Tracts were weighed and morphometrics were taken on uterine horn length and width, and the zone of placentation was measured in postpartum females. Nine of the 10 tracts sampled were postpartum. The ovaries were removed and gross dissections were conducted to remove corpora lutea (CL) and corpora albicantia (CA). Histological sections were taken from all CL and CA. CL progesterone concentration was measured against CL size, tract weight, age of the animal, the number of follicles present on each ovary, and harvest date. Walruses ranged from 7-22 years of age. One to seven CL and CA were obtained from each animal and all animals were sexually mature. There were no differences in the side of the reproductive tract that most recently ovulated. An attempt was made to determine the number of corpora over the lifespan of each walrus. This study will shed light on some of the endocrinological biomarkers controlling reproduction in walruses.

Bowhead Whale Songs in the Chukchi Sea and Canadian High Arctic Recorded July-October, 2013

Hannah Kimber, Josh Jones, Michael Mahoney, John Hildebrand, Bruce Thayre, Robert Small, Sean Wiggins, John Hildebrand

Presenter: Hannah Kimber

Email: hannah.kimber@gmail.com

Bowhead whale songs in the Chukchi Sea and Canadian High Arctic recorded July-October, 2013. This study compares acoustic detections of bowhead whale songs recorded in the Northeast Chukchi Sea and Barrow Strait in the Canadian High Arctic from July through October, 2013. Instruments at both locations recorded nearly year-round, but singing bouts were detected only in summer and fall. The songs were examined independently and compared between the two regions. All songs consisted of repeated sequences, each made up of multiple units. Upsweeps, downsweeps, and shrieks were present across sites. The Chukchi Sea recording site is located within the range of the Bering-Chukchi Beaufort (BCB) stock, while the Canadian Arctic location in Barrow Strait represents an extreme edge of the distributions of the BCB and Baffin-Davis Strait stocks. The similarities and differences in the songs were evaluated to assess potential overlap between the two stocks in the central Canadian Arctic.

The University of Alaska Museum's Rapidly Growing and Increasingly Utilized Marine Mammal Collection

Aren Gunderson, Catherine Rubin, Kyndall Hildebrandt, Link Olson

Presenter: Link Olson

Email: leolson@alaska.edu

With over 125,000 catalogued specimens, the University of Alaska Museum (UAM) houses the 8th-largest mammal collection in North America and is the foremost repository of marine mammal specimens in the U.S., with material from over 21,000 cetaceans, pinnipeds, sea otters, and polar bears. Most of these are represented by frozen tissue samples in the museum's state-of-the-art Genomic Resources facility. In addition to granting regular physical access to specimens, UAM's Department of Mammalogy provides samples from over 1,000 specimens to researchers around the world each year. Recent grants from the North Pacific Research Board and the National Science Foundation are supporting the archival and digitization of over 20,000 marine mammal specimens that remain uncatalogued and therefore unavailable to researchers. Upon completion of these projects, the marine mammal collection at UAM will nearly double in size. We will provide an overview of the current marine mammal specimen holdings, recent research using UAM's marine mammal specimens, and opportunities for new and strengthened partnerships between UAM and Alaska's diverse marine mammal stakeholders.

Examining Eastern Chukchi Sea Beluga Foraging Ecology Using Stable Isotopes (Multiple Tissues) and Blubber Fatty Acids

Heather Smith, Robert Suydam, Glenn VanBlaricom, Sara Iverson

Presenter: Heather Smith

Email: heathersmith.r@gmail.com

Diet of Eastern Chukchi Sea belugas is poorly known given that it is currently based on the analysis of a limited number of stomachs from whales taken in subsistence hunts in summering areas. Despite the relatively large number of stomachs available from subsistence-caught whales, the majority of these stomachs are uninformative because they are empty. As well, stomach contents analysis suffers from several well-known biases, limiting our understanding of beluga foraging and thus our ability to identify key prey species and important habitats. Information about important prey species and habitat are necessary for evaluating effects of environmental change on belugas, and developing conservation and management strategies for this species which remains an important subsistence resource. We used indirect diet methods (stable isotope and fatty acid analyses) to complement what has been learned about beluga diet from stomach contents. We collected multiple tissue samples (bone, skin, muscle, liver, and blubber) from >100 belugas taken in subsistence hunts near Point Lay, in NW Alaska, between 2002 and 2012. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope measurements were used to examine possible within-population differences in foraging location and trophic level. In general, foraging location, as indicated by $\delta^{13}C$, was not found to vary between years or by sex. However, trophic level, as indicated by $\delta^{15}N$, differed among years, and males had greater $\delta^{15}N$ than females across all tissues sampled. Variation in fatty acid composition was greatest among sampling years and beluga age. Our results indicate that class-specific dietary variation exists within the population of belugas studied. The next step will be to compare our results with stable isotope and fatty acid data from prey items likely consumed by these belugas.

All Harassment Take Estimates are Fictional, and What We Can Do About It

David Steckler

Presenter: David Steckler

Email: davidsteckler@gmail.com

The Marine Mammal Protection Act (MMPA) itself is rather vague about what causes harm or behavioral changes to animals with respect to acoustic impacts. Regulatory agencies (e.g. NMFS) have interpreted the MMPA, implementing thresholds for instantaneous and cumulative received sound levels deemed to be Level B harassment or Level A harm/injury. Esteemed biologists have weighed in on the subject (Southall et. al.), and an entire industry spanning for-profit, non-profit and academic interests has sprung up providing software and services related to Take Estimation of sound-producing activities. Respected computer scientists have crafted a number of software packages (e.g. AIM, ESME, 3MB, Mysticetus, etc.). These highly precise applications are used to generate Take Estimates. Billion dollar economic decisions are made based on the output of these models. A comparative analysis performed of the data input to these computer models found that the input data stretched beyond reason, requiring modelers to apply a variety of essentially unsubstantiated assumptions about animal distribution and behavior (e.g. dive behavior, presence/absence on a relative micro-scale). Slightly changing a single assumption can vary Take Estimates by orders of magnitude with each run, incentivizing the input of ever more unsubstantiated assumptions (“gaming” the system). Herein, approaches are proposed to help resolve this situation through (a) a reduced focus by NMFS on Take Estimation as part of the permitting process (diminish incentives to game the system); (b) specific requirements for more formalized analysis of mitigation and monitoring efforts (e.g. meta-studies on the effectiveness of visual and PAM-based MMO activities); and (c) require collected marine mammal data be centralized in open, standards-compliant databases accessible by everyone. Ultimately, the solution is to improve overall knowledge of animal distribution, density, behavior and response to acoustic sources – with a long-term focus on generating real-world datasets appropriate for input into modern, complex computer systems.

Observations of Bowhead Whale Foraging near Barrow, Alaska, in 2015 Support the Krill Trap Model

Megan Ferguson, Stephen Okkonen, Janet Clarke, Amy Willoughby, Amelia Brower, Carin Ashjian, Craig George

Presenter: Megan Ferguson

Email: megan.ferguson@noaa.gov

The density, behavior, and group size distribution of bowhead whales over Barrow Canyon and the Beaufort Sea shelf near Barrow, AK, during late summer and fall exhibit interannual variability that may be partially explained by the presence of dense patches of euphausiids (krill) and copepod prey. The “krill trap” model theorizes that moderate to strong easterly winds cause upwelling that advects prey onto the shelf, which then become aggregated (“trapped”) when wind speed decreases or direction changes to westerly or southwesterly. Furthermore, the model predicts that during upwelling periods bowhead whales will be found in smaller groups, often in Barrow Canyon, whereas during krill trap active periods bowhead whales will be found in larger groups over the shelf. Between 26 August and 4 October 2015, the Aerial Surveys of Arctic Marine Mammals (ASAMM) project (funded and co-managed by BOEM, conducted by NOAA) found historically high densities of feeding bowhead whales on the shelf south of 72^{o}N, between Pt. Barrow and Cape Halkett (152^{o}-157^{o}W). During this period, ASAMM conducted 8 surveys totaling over 40 hrs and observed 672 total bowhead whales, 454 of which were either feeding or milling. The ratio of feeding/milling to total bowhead whales in 2015 (0.676) was second only to 2009 (0.732) in a time series of annual surveys beginning in 1989. ASAMM surveys were conducted on 6 of 8 krill trap active days in 2015; feeding/milling bowhead whales were observed on 5 of those surveys. During the active krill trap phase, the observed average and maximum bowhead whale group size was larger than at other times. A single survey was conducted during the upwelling phase and moderate numbers of bowhead whales were observed, none of which were feeding/milling. Comparison of bowhead whale group sizes on krill trap active days with data from surveys conducted 5 days prior showed that krill trap group sizes were larger, implying that the bowhead whale congregation response was rapid. All of the fall whales harvested near Barrow in 2015 had been feeding on euphausiids. ASAMM bowhead whale observations in 2015 support the krill trap model.

Chukchi and East Siberian Surveys (ChESS): Joint U.S.-Russian Aerial Surveys for Ice-associated Seals and Polar Bears, 2016

Erin Moreland, Michael Cameron, Paul Conn, Eric Regehr, Peter Boveng

Presenter: Erin Moreland

Email: erin.moreland@noaa.gov

Obtaining reliable abundance estimates for ice-associated seals and polar bears is vital for developing sound plans for management, conservation, and responses to potential environmental impacts of oil and gas activities and climate change. The Chukchi and East Siberian Surveys (ChESS) project addresses the most critical need for fundamental assessment data on these animals through a cooperative effort with the US Fish and Wildlife Service and Russian researchers. Surveys are planned for spring 2016 and will provide the first reliable abundance estimates of ringed and bearded seals throughout the Chukchi Sea and the first estimates in US waters since 2000. Polar bear data will complement existing USFWS mark-recapture efforts in the Chukchi Sea. Survey design along with novel data collection and statistical approaches will be presented.

Marine Mammal Acoustic Detections in the Northeastern Chukchi Sea from 2008 to 2015: A Synthesis

Julien Delarue, Bruce Martin, Xavier Mouy, David Hannay

Presenter: Julien Delarue

Email: julien.delarue@jasco.com

Marine mammal occurrence in the northeastern Chukchi Sea was assessed using acoustic data recorded from Oct 2008 to July 2015 during consecutive winter and summer monitoring programs. Although the emphasis of the programs was on bowhead and beluga whales and Pacific walruses due to their importance to subsistence communities and conservation status, other species detected included gray, fin, killer, humpback and minke whales as well as bearded, ringed and ribbon seals. Summer programs included 25-30 recorders deployed from early August until mid-October; winter programs included 7-15 recorders deployed from mid-October until the following summer. This currently represents the most extensive acoustic monitoring effort in the Arctic. Here we present a synthesis of nearly seven years of marine mammal acoustic detections. Fin, humpback, and minke whale detections were rare (though occurring annually) and are not discussed here. For all other regularly detected species, seasonal detections are described spatially and temporally using two metrics: the average daily number of call counts corrected for effort (number of recording days); or the daily proportion of time slices (duration dependent on season) containing calls. The results are compiled over 1-3 periods per year. These periods were selected for each species to reflect the seasonality of acoustic detections, which may in turn reflect the true occurrence of a species, seasonal changes in acoustic behavior or both. These results reflect overall patterns of occurrence that incorporate responses to a range of environmental variations. Ice seals were found to be year-round residents to the Chukchi Sea. Walruses and gray whales are seasonal residents with highly consistent patterns of occurrence in time and space. Killer whale detections were also seasonal but more variable. Bowhead and beluga whales' occurrence was driven by migratory movements, with the bulk of the detections constrained to the spring and fall migration. Although one can argue that the Chukchi Sea was already in a state of change during the study period, these results provide a form of baseline data against which future marine mammal observations can be compared.

Influence of Benthic Communities and Environmental Characteristics on Bearded Seal Habitat for Migration, Foraging, and Resting: A Multidisciplinary Analysis for the Synthesis of Arctic Research (SOAR) Project

Michael Cameron, Arny Blanchard, Peter Boveng, Justin Crawford, John Goodwin, Jacqueline Grebmeier, Stephen Jewett, Bob Lauth, Josh London, James Lovvorn, Brett McClintock, Brenda Norcross, Lori Quakenbush, Susan Schonberg, Alex Whiting

Presenter: Michael Cameron

Email: michael.cameron@noaa.gov

Bearded seals (*Erignathus barbatus*) are large carnivores, inhabiting circumpolar Arctic and sub-Arctic waters in relatively shallow water depths that are seasonally ice-covered. Their distribution appears to be strongly influenced by water depth and prey biomass and, to a lesser degree, by ice conditions during winter and spring. They are primarily benthic feeders, consuming a broad variety of epifaunal and infaunal invertebrates, and demersal fishes primarily at depths less than 200 m. Despite their importance to Alaska Native subsistence communities, and their prominent role as a benthic predator in arctic marine ecosystems, the habitat requirements of bearded seals are poorly documented. Identifying these habitat requirements is crucial to the assessment of potential impacts from industrial activities and from a loss of sea ice resulting from climate warming.

In 2009 - 2012, we tracked and recorded the diving behavior of seven subadult and adult bearded seals. We used a multi-state random walk model to estimate the transitions between states of behavior that are likely to be influenced by environmental conditions. We used both locations, dive summaries, and haul-out data to characterize behavior as resting (on ice, in the water or on land), foraging (benthic or mid-water) or transit. In this SOAR project, we will determine how these behavioral states are related to specific environmental and biological features (e.g., benthic prey composition, sediment type, ice concentration, distance to ice, water depth), with the goal of identifying biologically important areas (i.e., “hotspots”) and increasing our understanding of bearded seal habitat preferences and requirements in the northeastern Chukchi Sea.

Finding the Calls in the CHAOZ: Marine Mammals and Oceanographic Conditions off Alaska's Northern Slope

Jessica Crance, Catherine Berchok, Ellen Garland, Jeff Napp, Phyllis Stabeno

Presenter: Jessica Crance

Email: Jessica.Crance@noaa.gov

The Chukchi Acoustics, Oceanography, and Zooplankton (CHAOZ) study was a five-year BOEM-funded, multi-disciplinary study (2010-2015). Its primary objective was to document the distribution of large whales in areas of potential seismic activity, and to relate these changes to oceanographic conditions, indices of potential prey density, and anthropogenic activities. Results presented here focus on the relationship between marine mammal distributions and oceanographic conditions. Three clusters of passive acoustic and biophysical moorings were deployed at 40 nm, 70 nm, and 110 nm off Icy Cape, AK, and collected year-round passive acoustic data (16 kHz sampling rate, ~30% duty cycle) along with twelve different oceanographic measurements from two consecutive deployments (2010-2012). All acoustic recordings (100%) were analyzed using an in-house Matlab-based manual analysis program for twelve different Arctic and sub-Arctic cetacean and pinniped species, as well as for vessel, airgun, and ice noise. Generalized Additive Models (GAMs) were used to assess the effect of oceanographic conditions on marine mammal distribution, and marine mammal calling activity was plotted against eight oceanographic variables to determine if any positive/negative correlations existed on a temporal scale. Bowhead and beluga distributions showed similar patterns, with bimodal temporal distributions representing the fall and spring migrations. Ice concentration and month had the greatest effect on both bowhead and beluga presence, although bowheads were also strongly correlated with ice thickness and strong SSW winds. Gray whale detections (isolated on the inshore recorder) were too infrequent for conclusive results. Walrus and bearded seal calls were detected almost year-round; both species were correlated with ice concentration and variables that serve as proxies for prey availability. Detections of sub-Arctic species (e.g., humpback, fin, and killer whales) were rare. This study illustrates the importance of collecting concurrent passive acoustic and oceanographic data in a rapidly changing environment.

A Method for Estimating the Number of Pacific walruses (*Odobenus rosmarus divergens*) in the Northeastern Chukchi Sea during an Ice-Free Period

Chadwick Jay, Brian Battaile, Mark Udevitz, Anthony Fischbach

Presenter: Brian Battaile

Email: bbattaile@usgs.gov

The Pacific walrus is an important ecological and cultural component of the Chukchi and Bering Seas. Recent sea ice loss and oil and gas development in the walrus's summer habitat in the NE Chukchi Sea present potential threats to the population, and population size estimates are needed for Endangered Species Act and the National Environmental Protection Act decisions. We estimated the number of walruses in the NE Chukchi Sea in September 2014 by conducting photographic aerial surveys of the only major haulout that occurred after the sea ice receded beyond the continental shelf. To account for animals that were using the haulout but at sea during the aerial surveys, we tagged 37 walruses using the haulout and scaled survey counts based on recorded haulout behavior from walruses at the time of the surveys. We used both design and model-based estimates of the proportion of the population at the haulout to adjust the survey counts. We surveyed the haulout on 25 September and two times on 27 September resulting in estimates ranging from 4,200 (95%CI ±278) to 38,000 (95%CI ±1,498) individuals on land. Estimates of the total population using the haulout, including those at sea at the time of the aerial surveys, varied widely, depending on the survey time and the method used for estimating the proportion hauled out. This approach shows promise, but larger or more widely distributed samples of tagged walruses, as well as more survey flights would likely be required to generate robust estimates of the population of walruses using haulouts on the Alaskan Chukchi coast.

Operating UAS in the Arctic: Comparing Manned and Unmanned Surveys of Cetaceans

Robyn Angliss, Megan Ferguson, Laura San Filippo, Philip Hall, Van Helker, Jon Elliott, Lorenz Eber, Amy Kennedy

Presenter: Robyn Angliss

Email: robyn.angliss@noaa.gov

Manned aerial surveys are routinely used to collect data to infer cetacean distribution and density. Unmanned aerial systems (UAS) have been identified as a technology that could augment or replace manned aerial surveys for cetaceans. To understand what research questions can be addressed using current technology, a direct comparison of data collected by manned and UAS surveys are necessary. NOAA Fisheries' Alaska Fisheries Science Center led a collaborative effort that included the Bureau of Ocean Energy Management, US Navy, and Shell to conduct manned and unmanned aerial surveys for cetaceans near Barrow, Alaska. Field operations occurred from August 21 to September 7, 2015, using a twin turbine Aero Commander operated by Clearwater Air, Inc. and a ScanEagle UAS operated by the Naval Surface Warfare Center Dahlgren. The ScanEagle was operated under a Certificate of Authorization from the Federal Aviation Administration (FAA) that allowed beyond line-of-sight flights. The study design involved a three-way comparison among data collected by observers aboard the Aero Commander, imagery collected by a Nikon D810 camera system on the Aero Commander, and imagery collected by a similar camera system on the ScanEagle. The platforms each conducted 5 flights. Weather varied dramatically over small spatiotemporal scales, limiting flights by both platforms. Harsh environmental conditions increased the maintenance required for ScanEagle operations. Technology that directly contributed to the ability to conduct UAS flights in the study area included: software that provided a direct link to the FAA's radar system, which enabled de-confliction with local aircraft; temperature and humidity sensors on the ScanEagle; software that provided near-term forecasts of cloud cover and precipitation; and a portable weather station. Recommended changes for conducting long-range UAS surveys in the Arctic are discussed. To determine whether a particular UAS is an appropriate tool to meet a specific scientific objective, it will be critical to understand the logistic requirements, cost, and whether the expected data will adequately address the research question.

Bowhead Whale in the Bering Strait Region Found Entangled in Commercial Crab Pot Gear

Gay Sheffield, Savoonga Whaling Captains Association Savoonga Whaling Captains Assn., Raphaela Stimmelmayr, Craig George

Presenter: Gay Sheffield

Email: gay.sheffield@alaska.edu

Synopsis: Savoonga Whaling Captains Association (SWCA), University of Alaska-Marine Advisory Program (UAF-MAP), and the North Slope Borough, Department of Wildlife Management (NSB-DWM) worked together to document a floating bowhead whale found dead and entangled in nylon line and floats during July 2015, near Saint Lawrence Island, in the Bering Strait region.

An adult female bowhead (2015-FD2) floating dead was encountered July 7th, 2015 approximately 15-20 miles east of Savoonga on the north shore of Saint Lawrence Island by members of the Savoonga Whaling Captains association (SWCA). The observers noted two floats located under the fluke as well as lines wrapped around the peduncle region of the whale. SWCA members recovered all available gear for documentation. Recovered gear included: three colored lines of ¾" or 7/8" diameter for a minimum total of 133' of line, two inflatable vinyl floats, and a color-coded permit tag issued by ADF&G Commercial Fisheries Division at Dutch Harbor for the Bering Sea Aleutian Islands Saint Matthew Island 2012-2013 winter season blue king crab commercial fishery. Based on all observations and the level of detail provided by the recovered equipment, bowhead whale 2015-FD2 had been entangled in commercial crab fishery gear prior to death. This is the first documentation of a bowhead whale snared in fisheries gear that provided the specific fishery as well as the potential origin of entanglement.

Lessons learned:

Detection of large whale strandings and entanglements in remote coastal areas is likely to occur by people actively engaged in the utilization of those resources.

Remote response capacity by authorized state and federal wildlife agencies located in urban centers is most efficient and comprehensive when integrated with existing regional communication networks.

Entanglement of large whales in fishery gear in northern and western Alaska cannot be viewed solely as a wildlife conservation concern. Rather, investigations must consider research strategies and management issues – in terms of food security concerns.

Determining the origin of fishing gear recovered from any dead whale (harvested or not) is a priority in order to obtain information that may mitigate entanglements.

Thar She Blows: Wind as a Predictor of Bowhead Whale Habitat Use in the Canadian Beaufort Sea

Deanna Leonard, Lara Horstmann, Lois Harwood

Presenter: Deanna Leonard

Email: dmleonard2@alaska.edu

This study models the habitat use of the Bering-Chukchi-Beaufort (BCB) bowhead whale population on their late summer range in the southeast Canadian Beaufort Sea. Bowhead whales of the BCB population winter in the Bering Sea and migrate to summer feeding areas in the Canadian Beaufort Sea and Amundsen Gulf. In late-July, they begin to aggregate in coastal waters off the Canadian Beaufort Shelf to feed on their preferred prey, crustaceous zooplankton, which become concentrated by oceanographic processes. Extensive aerial surveys conducted throughout the Canadian Beaufort Sea in the 1980s and 2000s reveal that whales repeatedly use the same areas; however, the use of any specific area varies among years. In this study, patterns of bowhead distribution and associated inter-annual variation are examined retrospectively, in relation to archived oceanographic data for the same time periods. Bowhead distribution is being modelled with covariates including bathymetry, sea surface temperature (SST), wind stress, and frontal features, such as salinity and temperature gradients. Preliminary data analyses show that wind speed and direction are correlated to bowhead whale distribution and may be reliable indicators of bowhead whale habitat use. Habitat models incorporating oceanographic variability can be used to develop predictions of habitat use and derive ecological insight from a species' distribution. This study is an important step toward adaptive management and may contribute to a broader understanding of how bowhead whales respond to factors that alter their habitat.

Arctic - Mammals

Calcium Oxalate Urolithiasis in a Bowhead Whale: A Case Report

Raphaela Stimmelmayr

Presenter: Raphaela Stimmelmayr

Email: Raphaela.Stimmelmayr@north-slope.org

Nephrolithiasis has been reported in toothed whales but not in baleen whales. In fall 2014, nephroliths (~ 20) of varying sizes ranging from <1- 4.1 mm in diameter were observed in the kidney a subsistence harvested immature female bowhead whale. The nephroliths were composed of 100 % calcium oxalate. We can only speculate on the underlying risk factors leading to calcium stone formation in this bowhead whale, but hypocitraturia is a known metabolic risk factor in other species including dolphins that facilitates the formation of urinary stones. This is the first report of calcium oxalate nephrolithiasis in a baleen whale.

Mesenteric Torsion in Pacific Walrus

Raphaela Stimmelmayr, Anna Bryan

Presenter: Raphaela Stimmelmayr

Email: Raphaela.Stimmelmayr@north-slope.org

On necropsy, one yearling and one walrus calf that were investigated as part of the 2014 Point Lay (69.7328889 / -163.0053333) walrus haul out mortality (2-5th October, 2014) presented with complete mesenteric torsion (Case # 29 six 360 Degree turns and #31 three 360 degree turns) as well as epistaxis, extensive muscular bruising (head and neck region), renal and lung hematoma (#31), congested enlarged spleens (both). Both animals were males, in good body condition and had empty stomachs and intestines. Mesenteric torsion is the twisting of the intestines around the mesenteric axis. We speculate that observed mesenteric torsions were triggered about by being “rolled” during the preceding stampede event. Due to carcass condition and tissue autolysis we could not determine if these torsions would have been clinically relevant and thus could have contributed to cause of death. Stampede associated occurrence of mesenteric torsion in young walruses has not been reported previously among commonly reported gross findings of mortality due to trampling. Interestingly, mesenteric torsion of fewer degrees (~ 2-3) were also observed in several walrus calves during the recent 2015 *Cape Lisburne* haul out mortality investigation (Carrie Goertz and Stimmelmayr unpubl. data). Thus stampede associated mesenteric torsion may be more common than previously documented. We suggest that during field examination of haul out mortalities by biologists and/or veterinarians’ examination of body cavities is included as part of the standard forensic protocol to document stampede associated internal injuries.

Physiology and Health of Cooperating Arctic Seals (PHOCAS)

Nicole Thometz, David Rosen, Colleen Reichmuth

Presenter: Colleen Reichmuth

Email: coll@ucsc.edu

The Arctic region has become one of the most graphic examples of the effects of climate change. Sea ice loss is progressing at an unprecedented rate, ice-dependent seals, including ringed (*Pusa hispida*), bearded (*Erignathus barbatus*), and spotted (*Phoca largha*) seals may be particularly ill-equipped to tolerate such rapid environmental transformation. These high tropic level predators exert top-down control within Arctic ecosystems and are of critical importance to subsistence communities. Unfortunately, much remains to be learned about their basic biology and physiology. As a result, management agencies and conservation practitioners have an incomplete understanding of the physiological requirements and limitations of these species, and thus, have a weak ability to make predictions about the capacity of ice-dependent seals to respond to rapidly changing environmental conditions. Currently, it is difficult or impossible to collect many types of physiological data from ice-dependent seals in the wild, which makes information gained from captive individuals vital to the conservation and management of these species. We have recently developed a cooperative research program between the Long Marine Lab in Santa Cruz, California, and the Alaska SeaLife Center in Seward, Alaska to work with and study the largest population of captive ice-dependent seals in the world, in order to obtain valuable information about their biology and physiology. The broad objectives for this partnership are to determine short- and long-term energetic requirements, define thermal strategies and limitations, and describe the molting physiology of ringed, bearded, and spotted seals. In addition, we will examine and quantify specific physiological constraints to diving and foraging for each species. Ultimately, these comparative data will be used to more accurately determine habitat requirements, define physiological limitations, and predict species' resilience to changing conditions in the Arctic. Data from this research program should ultimately provide fundamental information to managers and conservation practitioners attempting to understand and predict population-level consequences of environmental change and support efforts to take appropriate action.

Ventral and Dorsal Blubber Topography in a Neonate Pacific Walrus: Which Blubber Depth Measurement is Best?

Raphaela Stimmelmayr, Carolyn Neilson, Nathan Wilen

Presenter: Raphaela Stimmelmayr

Email: Raphaela.Stimmelmayr@north-slope.org

Using ultrasound, body site specific variations in blubber thickness have been recently demonstrated in captive mature female walruses. Results indicated that dorsomedial blubber thickness measurements between the shoulders were a good fit for overall body condition while sternum blubber thickness was a poor indicator. Carcass body condition assessment is important aspect for subsistence harvest monitoring programs as well as during investigations of mortalities due to stampedes. Demographically calves, yearling and subadult walrus are among the most commonly observed fatalities during haul-out associated mortalities. Fat deposition pattern in young pacific Walrus may differ due to different body growth requirements. In situ ventral midline and dorsomedial blubber thickness measurements were taken in a freshly dead neonate male walrus pup (July 2015; <1 month, body mass 53 kg; TBL 109 cm; umbilical stump present) along the 7 girth measurements as previously described by Noren et al. 2014. Briefly, girth measurements were taken with a survey tape. To measure blubber thickness stab incisions were made through the skin and blubber. Depth of stab incision was guided by visualizing the muscle layer. Using a measured ruler blubber thickness was measured including skin. Results: Maximum blubber thickness dorsomedial was 1.7 cm and was observed at girth #1 (neck taken behind base), 2 (anterior flippers in front), and #7 (hips). Maximum blubber thickness ventral midline was 2.3 cm (including skin) and was observed at girth #4 (anterior teats). In comparison sternal thickness was only 1.8 cm. Skin thickness measurements at different girth sites ranged dorsomedial between 0.7-0.9 cm and ventral-midline 0.6-0.8 cm. The measured sternal blubber thickness measurement falls within the range of previously reported blubber measurements during the month of May (Fay 1982). Body condition of the pup was assessed as fair. Based on the limited data site of maximum fat depth in a neonate appears to differ from a mature female walrus with ventral midline at the anterior teats providing maximum blubber thickness. Additional field validation efforts need to be undertaken to clarify the optimum blubber thickness measurement for young walruses i.e. neonates, calves, and yearlings.

Foraging Behavior of SBS Polar Bears on the North Slope: Stomach Content Analysis in Subsistence Harvested Polar Bears and Direct Feeding Observations

Raphaela Stimmelmayr, Mike Pederson, Billy Adams, Robert Sarren, Harry Brower, Jr.

Presenter: Raphaela Stimmelmayr

Email: Raphaela.Stimmelmayr@north-slope.org

Polar bears of the Southern Beaufort and Chukchi Sea are an important Arctic subsistence food and cultural-spiritual resources for Inupiaq, Inualuvuit, and Chukotkan hunters alike. To better understand cumulative stressor effects on the health and well-being of the SBS polar bears, opportunistic community based monitoring efforts of polar bear subsistence harvest on the North Slope have been intensified in recent years to support a comprehensive prospective health assessment, as well as provide important data on life history and foraging ecology to better understand how polar bears (individual/population) respond to a rapidly changing Arctic. We present preliminary diet data for SBS polar bears based on gross stomach content examination from subsistence harvested polar bears and direct observations of feeding behavior. Preliminary findings from stomach content analysis and direct field observations: before and after the open water season, marine mammal based food items (i.e. bowhead/grey whale carcasses; ringed/spotted seal; Pacific walrus) are predominant, while during the open water season non marine mammal based food items (i.e. seabirds etc.) and vegetation (i.e. tundra grass; beach plants, wood etc.) were consumed. Our preliminary data on diet items consumed by polar bears during the open water period is in agreement with recent polar bear scat data from the Western Hudson polar bear population. Summer feeding plasticity in polar bears has been viewed as a response to climate change. Available evidence of historical stomach content data from non-subsistence harvested polar bears from Franz Josef Land, and traditional ecological knowledge on polar bear feeding behavior from Inuvialuit and Inupiaq suggests that summer feeding plasticity is not new to polar bears.

WAVE 2

Monday, January 25
7:15 pm – 8:30 pm

Arctic - Fishes and Fish Habitats

Marine Behavior and Movements of Dolly Varden in Arctic Alaska

Andrew Seitz, Brendan Scanlon, Randy Brown, Michael Courtney

Presenter: Michael Courtney

Email: mbcourtney@alaska.edu

In Arctic Alaska, Dolly Varden *Salvelinus malma* is highly valued as a subsistence fish; however, little is known about its marine ecology. Therefore, we are using pop-up satellite archival tags (PSATs) to study the oceanic habits, distribution and migration patterns of Dolly Varden that spend summers in the Beaufort Sea. While attached to a fish, the PSATs collect temperature, depth and ambient light data (for daily geoposition estimates), after which they release from the fish and transmit the collected data and provide an end location to satellites. To date, we have tagged and released 34 Dolly Varden (54–81 cm) in both freshwater (n = 18) and nearshore marine waters (n = 16). Preliminary results show several different dispersal types including foregoing an oceanic migration, movement in nearshore and offshore marine waters, and movement to several rivers on Alaska's North Slope. Information gained from this study has the ability to inform future management considerations by subsistence users, biological resource managers, and mineral and energy developers and regulators.

New Estimates of Growth, Size of Maturity, Mortality and Biomass of Snow Crab, *Chionoecetes opilio*, in the Arctic Ocean off Alaska

Lauren Divine, Franz Mueter, Gordon Kruse, Bodil Bluhm, Katrin Iken

Presenter: Lauren Divine

Email: lmdivine@alaska.edu

Although a moratorium currently prohibits commercial fishing in federal waters of the Arctic Ocean off Alaska, snow crabs (*Chionoecetes opilio*) were identified as a potential future target fisheries species in the Arctic Fishery Management Plan (Arctic FMP), released by the North Pacific Fishery Management Council in 2009. The Arctic FMP was based on limited snow crab data from the Chukchi and Beaufort seas and applied population dynamic parameters based on observations from the eastern Bering Sea stock. Since publication of the Arctic FMP, collaborative efforts in the Chukchi and Beaufort seas have provided new information upon which to estimate parameters specific to Arctic snow crab. Following methods used in the Arctic FMP, we re-estimated growth and size at maturity based on data collected from male and female crabs from the Chukchi and Beaufort seas since 2004. Size-based catch curves were then constructed to estimate natural mortality rates. We calculated catch per unit effort (CPUE) (kg km^{-2}) for each station surveyed, estimated regional average CPUE, and obtained an area-weighted total biomass estimate for each sea. New estimates of snow crab stock biomass and abundance in the Alaska Arctic were separated into harvestable and non-harvestable proportions by dividing the cumulative weights of male crabs > 78 mm carapace width (minimum legal size limit in the Bering Sea fisheries) by the total cumulative weights of all crabs measured. Using these new parameters estimated for Arctic snow crab, we reconstructed Thompson's (1992) simple dynamic pool model to examine changes in total and harvestable biomass from previous estimates that were based on Bering Sea parameters. Our new estimates of snow crab stock biomass and abundance in the Alaska Arctic provide the best scientific data available to inform the management of this stock and to improve our understanding of Arctic snow crab dynamics in light of potential fisheries or other, non-fishing activities.

Otolith Length-Fish Length Relationships of Eleven Beaufort and Chukchi Sea Fish Species and Their Application to Marine Mammal Diet Studies

Kelly Walker, Brenda Norcross

Presenter: Kelly Walker

Email: klwalker2@alaska.edu

The Arctic ecosystem has moved into the spotlight of scientific research in recent years due to increased oil and gas exploration and climate change. Arctic fishes and Arctic marine mammals represent key parts of this ecosystem, with fish being a common part of ice seal diets in the Arctic. Determining sizes of fish consumed by ice seals is difficult because otoliths are often the only part left of the fish after digestion. Otolith length is known to be positively related to fish length. By developing species-specific otolith-body morphometric relationships for Arctic marine fishes, fish length can be determined for fish prey found in seal stomachs. Fish were collected during ice free months in the Beaufort and Chukchi seas 2009 – 2014, and the most prevalent species captured during these years were chosen for analysis. Otoliths from eleven fish species from seven families were measured. All species had strong linear relationships between otolith length and fish total length. Ten species had coefficient of determination values over 0.75, indicating that most of the variability in the otolith length-fish length relationship was explained by the linear regression. These relationships will be applied to otoliths found in stomachs of three species of ice seals (spotted *Phoca largha*, ringed *Pusa hispida*, and bearded *Erignathus barbatus*) and used to estimate fish total length at time of consumption. Fish lengths can in turn be used to calculate fish weight, enabling further investigation into ice seal energetic demands. This application will aid in understanding how ice seals interact with fish communities in the US Arctic. A better understanding of predator-prey interactions in the US Arctic will aid in predicting how ice seal and fish species will adapt to a changing Arctic.

Environmental Drivers of Inter-Annual Variability in Beaufort Sea Marine Fish Community Structure

Andy Majewski, Sheila Atchison, Jane Eert, Mike Dempsey, Shannon MacPhee, Christine Michel, Jim Reist

Presenter: Andy Majewski

Email: andrew.majewski@dfo-mpo.gc.ca

The Beaufort Sea is a complex and dynamic system influenced by a wide suite of oceanic and riverine inputs that affect the ecosystem. Interactions within the resulting water masses are largely driven by factors such as precipitation, wind, and ice cover. Thus, the Beaufort Sea environment is highly variable in both space and time, and this variability is reflected in the habitats of biota. Inherent system variability must be factored into baselines designed to detect changes resulting from anthropogenic stressors and natural drivers. Between 2012 and 2014, Fisheries and Oceans Canada conducted the first baseline survey of offshore marine fishes, their habitats, and ecological relationships in the Canadian Beaufort Sea. In 2012, benthic trawling was conducted at 28 stations spanning 20-1000 m depths across shelf and slope habitats, and selected stations were re-sampled in 2013 and 2014. Concurrent sampling of oceanographic parameters and sediment composition was conducted at each station. We examine the stability of marine fish assemblages over a three-year period, and compare results for shelf stations to previous research to develop longer-term perspectives. Oceanographic (e.g., salinity), physical (e.g., depth and sediment grain size) and geographic (e.g., distance from shore) parameters, and proxies for local productivity (i.e., water-column and benthic chlorophyll) are explored as explanatory variables affecting fish community structure among years. Establishing knowledge baselines and understanding variability in the community structure and habitat associations of Beaufort Sea marine fishes will support mitigation and conservation efforts by enhancing our ability to predict, detect and monitor the effects of hydrocarbon development and climate change on this pivotal ecosystem component.

Temperature-dependent Lipid Storage in Juvenile Arctic and Temperate Cod Species

Louise Copeman, Benjamin Laurel

Presenter: Benjamin Laurel

Email: Ben.Laurel@noaa.gov

Climate change impacts on Arctic fish communities will largely be determined by temperature-dependent vital rates of resident and invading species. In this study, we experimentally measured total lipids and lipid class storage in the liver and muscle of juvenile Arctic gadids (Arctic cod, *Boreogadus saida* and saffron cod, *Eleginus gracilis*) and two North Pacific gadids (walleye pollock, *Gadus chalcogrammus* and Pacific cod, *Gadus macrocephalus*). Experiments were conducted over a 6-wk period across five temperatures (0, 5, 9, 16 and 20 °C) at the Hatfield Marine Science Center in Newport, OR, USA. Results indicated clear physiological differences among species with Arctic cod demonstrated a cold-water, stenothermic response. Arctic cod showed positive growth and relatively high lipid storage (27 mg/g WW) at 0 °C with limited growth beyond 5 °C and high mortality above 9 °C. In contrast, saffron cod demonstrated a warmer-water, eurythermic response with elevated growth at temperatures beyond 16 °C. However, saffron cod showed relatively low lipid storage at all temperatures with only slightly higher lipid storage at warm temperatures (10 to 17 mg/g WW). Both walleye pollock and Pacific cod showed a domed response with increased lipid storage at intermediate temperatures and low lipid storage at cold and warm maxima. Pacific cod had maximum lipid storage at 9 °C (27 mg/g) while walleye pollock had maximum lipid storage at warmer temperatures (12 °C, 44 mg/g). We did not observe a trade-off between growth rate and lipid accumulation while the two temperate species demonstrated a significant positive relationship between growth rate and lipid storage. These results suggest that Arctic cod are highly vulnerable to continued warming, especially in coastal areas of the Beaufort and Chukchi seas where temperatures already exceed 14 °C in the summer growth period.

A Description of Arctic Cod, *Boreogadus saida*, Growth Rates from the Chukchi and Beaufort Seas

Alyssa Frothingham, Brenda Norcross

Presenter: Alyssa Frothingham

Email: afrothingham@alaska.edu

Dramatic changes to the Arctic have highlighted the need for a greater understanding of the present ecosystem. Arctic Cod, *Boreogadus saida*, commonly dominate fish assemblages in the Arctic region and inhabit two geographically unique seas in the U.S. Due to the importance of Arctic Cod in the Arctic food web, establishing current benchmark information such as growth rates, will provide a better understanding as to how the species will adapt to the effects of climate change. To investigate differences in Arctic Cod life history across nearly 1500 km of vital habitat, growth rates were examined using a von Bertalanffy growth equation. Arctic Cod were collected from 2009 to 2014 from the Chukchi and Beaufort seas. Arctic Cod collected from the Chukchi Sea had an overall smaller maximum achievable length (210 mm) when compared to the Beaufort Sea (253 mm) despite a larger sample size in the Chukchi Sea (n=1569) than the Beaufort Sea (n=1140). Growth rates indicated faster growth in the Chukchi Sea (K =0.33) than in the Beaufort Sea (K= 0.29). Arctic Cod collected from the Chukchi Sea had similar achievable maximum lengths throughout, but those collected from the southern Chukchi Sea grew at faster rates (K=0.45). Arctic Cod in the eastern Beaufort Sea region had a higher overall maximum achievable length (243 mm) potentially suggesting favorable conditions in this region for Arctic Cod. Knowledge about contemporary growth rates of Arctic Cod in the Chukchi and Beaufort Seas can be used in future comparisons to evaluate potential effects of increasing climate change and anthropogenic influences.

Can Catch Data from Different Gears be Combined? A Comparison of Fish and Invertebrate Data from Two Small Demersal Beam Trawls in the Beaufort Sea

Lorena Edenfield, Katrin Iken, Brenda Norcross

Presenter: Lorena Edenfield

Email: leedenfield@alaska.edu

The US and Canada have each conducted multi-year sampling of seafloor fauna in the Beaufort Sea using small demersal beam trawls in recent years. During the BOEM US-Canada Transboundary Fish and Lower Trophic Communities program 2012–2014, US researchers collected benthic fish and invertebrates from near Prudhoe Bay to the Mackenzie River mouth and Canadian scientists collected the same material in the Beaufort Regional Environmental Assessment from the US-Canada border to Amundsen Gulf. We compared the resulting benthic invertebrate and fish communities sampled in 2013 using two 3-m beam trawls with different mesh sizes. Samples were collected at 42 locations along 6 shelf-to-slope transects (136.7 °W–146.1°W) at depths ranging from 20 to 1000 m near and west of the Mackenzie River outflow with both beam trawls. Differences in standardized catch per unit effort between gears were examined using nonparametric analyses. Based on our findings, catches between the two beam trawls can be considered indistinguishable in terms of the abundance, biomass, and overall community composition captured. Further analysis revealed that depth was a significant factor in catch composition of benthic fauna. There were no significant differences in fish sizes or taxa captured between the gears. Thus, direct comparisons of data collected from both programs can be made. This information improves our ability to examine fish and benthic invertebrate communities across the entire Beaufort Sea from Pt. Barrow in the west to Amundson Gulf in the east by allowing direct comparison between two distinct research programs.

Summer Diet of Four Arctic Eelpout Species in the Beaufort Sea

Sarah Apsens, Brenda Norcross

Presenter: Sarah Apsens

Email: sjapsens@alaska.edu

Eelpouts of the genus *Lycodes* are a group of demersal fish commonly found in the U.S. Beaufort Sea. They are relatively numerous, having composed a significant proportion of fish catch during trawl surveys. Eelpouts are consumed by marine mammals and birds, and like other fish in the Arctic, serve as an important link between low and high trophic levels. Currently, however, their exact role in the Arctic food web is still poorly understood. Additionally, how environmental factors like depth and longitude impact eelpout diet is not known. Percent number (%N) and percent weight (%W) were used to describe diet, and multivariate techniques were used to look for patterns across environmental (depth and longitude) and biological (length) gradients. Fish were collected in August and September of 2012 and 2014 as part of the U.S.-Canada Transboundary cruises. Stomachs from four eelpout species were examined: Adolf's Eelpout *Lycodes adolfi,* Canadian Eelpout *L. polaris,* Archers Eelpout *L. sagittarius,* and Longear Eelpout *L. seminudus.* Polychaetes, benthic amphipods, brittle stars, and harpacticoid copepods composed a large part of the observed diet for all four *Lycodes* species, but proportions differed by species. Intraspecific similarity was low, suggesting these fish have diverse diets even among individuals of the same species. Fish total length was found to be correlated with diet composition for all fish species examined except *L. seminudus*. Longitude and depth were found to be correlated with diet for *L. sagittarius*. Identifying prey and factors influencing diet are initial steps towards characterizing the ecological role of this fish genus in the U.S. Arctic food web. Ecological information on abundant but not necessarily economically or culturally important fish species is needed for the development of ecosystem-based management practices. Establishing a benchmark for this group is important for understanding their current and future role in the rapidly changing Arctic food web.

The Effect of Temperature and Food Availability on the Growth, Condition, and Survival of Larval Arctic Cod and Walleye Pollock

Brittany Koenker, Louise Copeman, Benjamin Laurel

Presenter: Benjamin Laurel

Email: Ben.Laurel@noaa.gov

Accurate forecasting of the environmental impacts of climate change on food webs in the Arctic is limited by our understanding of the physiological response of marine fish to changes in temperature and food availability. Both Arctic cod (*Boreogadus saida*) and walleye pollock (*Gadus chalcogrammus*) co-occur in the North Bering Sea and Chukchi Sea but field sampling of larvae is limited by sea-ice cover in the spring. In laboratory studies, we examined larval growth, survival and condition of these two species in response to predicted changes in temperature and food availability. Larvae of both species were cultured from eggs in the laboratory and reared in replicated tanks across five temperature treatments (0 – 9 °C, Arctic cod; 0 – 12 °C, walleye pollock) receiving high food rations, with an additional set of low ration treatments conducted at 2 °C, 5 °C and 9 °C. After 2 weeks under experimental conditions both species showed a significant positive growth response to increases in culture temperature. In addition, both species had significantly higher growth rates at high prey densities compared to low prey densities within a given temperature. The impact of prey density on growth rate was more pronounced in both species at 5°C than at other temperatures. Arctic cod had a narrower thermal tolerance than walleye pollock, with extremely high mortality rates within the first week of culture at temperatures > 5 °C. Walleye pollock mortality rates were highest at temperatures < 5 °C, with the most extreme mortality occurring at 0 °C. Collectively, these data indicate significantly different growth and survival responses to varying temperature and food scenarios. Ongoing lipid analyses of larvae from these experiments will provide further insight into the condition and energetic value of these species in response to environmental changes in the Arctic.

Tissue-Dependent Stable Isotope Analysis of Arctic Sculpin (*Myoxocephalus scorpioides*) to Assess Local Seasonal Variability in Prey Availability

Mark Barton, Kevin Boswell, Johanna Vollenweider, Ron Heintz, Brenda Norcross

Presenter: Mark Barton

Email: mbart034@fiu.edu

Nearshore Arctic marine ecosystems face imminent threats from climate change and increasing anthropogenic impacts. It is likely that the associated environmental changes will affect the abundances of different prey resources as tolerable ranges expand, contract, and shift; but it is unclear how this will affect the predators of the Arctic nearshore. Stable isotope analysis of more charismatic and well-studied plankton and nekton species (i.e. Krill, Arctic cod and capelin) are not likely to indicate site-specific temporal changes in prey resources due to their low site fidelity and ability to follow preferred prey types across relatively broad spatial scales. The ubiquitous distribution, high site-fidelity, and opportunistic feeding of Arctic sculpin (*Myoxocephalus scorpioides*) make it an ideal candidate as a bio-indicator to examine site-specific effects of environmental change on prey availability. Juvenile *M. scorpioides* (n=81) were used in a growth and feeding experiment to determine stable carbon and nitrogen isotope incorporation rates in liver, muscle and fin tissues. We use results from the experiments to give temporal context to isotopic shifts in tissues from *M. scorpioides* collected during the summers of 2013 and 2014 from the Point Barrow, AK region to examine the natural variability in prey resources across rapidly changing environmental conditions associated with land-fast ice break-up. In order to make large scale predictions about changes in prey resources we must first understand this small-scale seasonal variability and the environmental factors that drive these changes.

Ichthyoplankton Assemblages and Distribution in the Chukchi Sea 2012-2013

Morgan Busby, Heather Tabisola, Janet Duffy-Anderson, Kathy Mier

Presenter: Heather Tabisola

Email: heather.tabisola@noaa.gov

There is significant interest in the effects of climate change on the Pacific arctic ecosystem, and in determining relationships between physical drivers and biological response. Ichthyoplankton surveys have become an integral component of ecosystem studies in the Pacific arctic over the past decade. In summer 2012 and 2013, large scale fisheries oceanographic surveys that included ichthyoplankton tows were conducted in the northern Bering and eastern Chukchi Seas as part of the Arctic Ecosystem Integrated Survey (Arctic Eis). Spatial and temporal analyses of fish larvae collected determined that yellowfin sole (*Limanda aspera*) was the most abundant larval fish caught followed by Arctic cod (*Boreogadus saida*). Cluster analyses showed *L. aspera* to be the dominant component of a southern, nearshore assemblage strongly associated with the northward moving Alaska Coastal Current (ACC) characterized by relatively warm-low salinity water. *Boreogadus saida* larvae dominated a more northern assemblage in close proximity to the ice edge and were more abundant in 2013 than 2012. Collections of pelagic fish eggs determined locations of spawning centers for *L. aspera* nearshore of the Seward Peninsula and Bering flounder (*Hippoglossoides robustus*) to the west and offshore from Point Barrow in 2012. Similar but less pronounced trends in egg distribution were observed in 2013. Larvae of the forage fish species capelin (*Mallotus villosus*) and Arctic sand lance (*Ammodytes hexapterus*) were important assemblage components in 2012 and 2013 respectively. These patterns in the distribution of eggs and larvae are similar to those observed in other studies. The influence of circulation patterns on the distributions of fish in the Chukchi Sea is being investigated and will be discussed.

Growth Rates of Abundant Arctic Nearshore Fish Species With Respect to Environmental Conditions

Samuel George, Mark Barton, Stella Mosher, Ron Heintz, Johanna Vollenweider, Leandra Sousa, Adam Zenone

Presenter: Samuel George

Email: sjgeorge34@yahoo.com

Climate conditions in the Arctic are changing fast which may alter the local habitat. A change in one environmental variable can cause a domino effect throughout the system and lead to unpredictable changes in an already unpredictable environment. Nearshore fish communities are especially vulnerable to climate change due to their reliance on shallow water habitats as nurseries for developing fish larvae. We collected nearshore YOY and juvenile fish on a weekly basis during July and August of this year from the Chukchi and Beaufort seas and Elson Lagoon near Point Barrow, Alaska. Work this summer has shown that warming waters have caused a two week shift in the nearshore catches when compared to previous 2013 and 2014. Schools of capelin and saffron cod were showing up earlier in the summer. Relative species composition fluctuates weekly but there are a few ubiquitous species that can be used as a frame of reference. In Elson Lagoon, as well as some locations in the Chukchi, various sculpin species can be found. The neighboring Beaufort and Chukchi seas contain a regular amount of capelin and pacific sand lance. Growth rates will be used as an indicator of how well a species is doing relatively compared to its competitors. Their numbers and location will give a more detailed weekly history for comparisons. Primary independent variables are weather events, water temperature, and food abundance. It is not yet clear how these factors interact together but multiple regressions analysis will be used to evaluate any relationships. Comparisons will be done between sites of the same water mass, and before and after weather events and ice migrations.

Climate-Induced Changes in Arctic Cod and Saffron Cod Distributions May Alter Arctic Trophic Ecology

Stella Mosher, Johanna Vollenweider, Ron Heintz, Ben Laurel, Mark Barton, Ann Robertson, Matt Callahan, Sam George, Leandra Sousa, Franz Mueter, Kevin Boswell

Presenter: Stella Mosher

Email: stella.mosher@noaa.gov

Accelerated climate change at high latitudes may alter species distributions as tolerable habitat conditions change. Of specific concern are Arctic cod (*Boreogadus saida*) and saffron cod (*Eleginus gracilis*), two gadids that are critical prey items for marine predators including beluga whales (*Delphinapterus leucas*) and ringed seals (*Pusa hispida*). Prior studies indicate that warming temperatures may have greater consequences for Arctic cod, whose growth rates (% body weight per day) diminish at temperatures warmer than 7.3°C. In contrast, saffron cod are more resilient with growth rates not diminishing until temperatures exceed 14.8°C. We compared the energetic condition of Arctic cod and saffron cod to explore potential implications of warming ocean conditions for Arctic marine predators. In the summer months, YOY Arctic cod are 10.5% more energy rich (22.5 kJ/g) than YOY saffron cod (20.1 kJ/g), whereas age 1+ Arctic cod have 6% higher energy content (22.8 kJ/g) than age 1+ saffron cod (21.4 kJ/g). Differences in energy content are driven by lipid, with YOY Arctic cod having 49% more lipid (% lipid, wet mass) than YOY saffron cod, and age 1+ Arctic cod having 32% more lipid than age 1+ saffron cod. The energetic consequences of consuming these fish may vary depending on age class and the season in which they are consumed. At the greatest extreme, the energetic disparity between the two species would require predators to consume 100% more biomass of YOY saffron cod to acquire the same amount of lipid in their diet, or 12% more biomass of YOY saffron cod to acquire the same number of calories. The implications of these differences are unclear because Arctic cod and saffron cod occupy different habitats. Arctic cod are most abundant in offshore, cold and high-salinity Bering Sea/Anadyr water, while saffron cod are most frequently found in nearshore, warmer and low-salinity Alaska coastal current water.

Nearshore Seining in Coastal Waters of Kotzebue, Alaska

John Seigle, Alex Whiting, Laura Gutierrez, John Rose

Presenter: John Seigle

Email: jseigle@abrinc.com

The Science Program of the Northwest Arctic Borough (NAB) is collecting data to inform policy and management decisions regarding food security, resource development, and infrastructure. Of great interest to the program is the marine ecology of Kotzebue Sound, a highly productive system that provides the residents of the area with an abundance of marine organisms important in local subsistence harvests, including marine and anadromous fish. Despite previous surveys of Chukchi Sea coastal waters, knowledge gaps include the presence, density, behavior, and timing of habitat use by nearshore fishes in the coastal areas adjacent to river deltas and lagoons of Kotzebue Sound. ABR, Inc. — Environmental Research & Services is collaborating with the Native Village of Kotzebue in a pilot field survey to fill some of the data gaps on fishes, invertebrates, and marine habitat types in nearshore waters of Kotzebue, Alaska. Project objectives are to: (1) describe nearshore fishes in the shallow coastal zone in Kotzebue; (2) describe associated habitat at seining locations; and (3) provide an assessment of invertebrate communities at seining locations. We present preliminary findings from pilot field surveys in August and September 2015. We seined in shallow waters in 3 distinct habitat types during each of 2 sampling survey events. Although species richness differed little between sampling events, fish density by species differed by survey location and sampling event. Invertebrate assemblages were similar between sampling periods but differed by survey location. Nearshore waters like those in the NAB provide important foraging habitat, proximity to shelter, and overwintering habitat for all life stages of fish present in the region. Furthermore, young-of-the-year and juvenile fishes in nearshore coastal waters are an important food source for marine bird and mammals in the region. These results will provide direction in developing future investigations in other subsistence communities in Kotzebue Sound with the ultimate goal of providing baseline information important to assessing the potential impacts of changes in ocean conditions (e.g., temperature) and continued development in the region.

Ice, Ice, Maybe? Lessons Learned from Sampling Fish in Ice-Covered Marine Environments

Eric Wood, Lorena Edenfield, Katrin Iken, Brenda Norcross

Presenter: Eric Wood

Email: edwood@alaska.edu

Sampling during ice-covered seasons has always been troublesome for Arctic researchers. The planned scientific objectives must be balanced with program costs and site accessibility. As part of two BOEM funded projects, sampling was conducted in the spring of 2013, 2014, and 2015 in an attempt to examine fish presence and activity in ice-covered environments. Location and methods differed each year. Changes in sampling design were based on information gaps present in previous years of sampling. In 2013, under ice sampling took place in the nearshore environment off Barrow, Alaska with extensive shore-based support. Sampling utilized SCUBA and ROV observations as well as overnight gill net sets. In 2014, the nearshore environment off Kaktovik, Alaska was sampled with limited shore-based support and employed divers and gill nets. The 2015 R/V *Sikuliaq* ice trial, which took place in ice-covered areas of the northern Bering and southern Chukchi seas, used ship-based trawling with an Aluette pelagic net and an Isaacs-Kidd midwater net to collect small pelagic fishes. Each year presented its own set of challenges and successes, requiring an iterative approach to sampling design. Here, we present the benefits and drawbacks of each approach in an attempt to inform and improve future research involving sampling during ice-covered seasons.

Collaboration and Understanding in Arctic Marine Ecosystems: Networking Science, Local Communities, Educators, and Stakeholders to Exchange Sea Ice Knowledge

Lisa Sheffield Guy, Helen Wiggins, Robert Rich, Betsy Turner-Bogren, Janet Warburton, Sarah Bartholow

Presenter: Lisa Sheffield Guy

Email: lisa@arcus.org

The dramatic and rapid changes observed in the Arctic warrant a strategic and coordinated response. Collaboration across boundaries, including those between disciplines and institutions, is essential to leverage resources, provide holistic understanding, and develop adaptation strategies to address these changes. The Arctic Research Consortium of the United States (ARCUS) is a nonprofit membership organization with over 40 member institutions. For more than 25 years, ARCUS has served as a catalyst for interdisciplinary thinking, acting, and education leading to the development of highly collaborative partnerships. In Alaskan marine ecosystems, ARCUS has several on-going projects that highlight these successful partnerships. The Sea Ice Prediction Network, guided by a 13-member leadership team, coordinates and integrates sea ice predictions and communicates this knowledge to stakeholders. The team produces a monthly Sea Ice Outlook (SIO) for the September sea-ice minimum during June, July, and August. The outlook is based upon contributed observations and models, synthesized by the leadership team, and published online. An in-depth post-season analysis is also produced each year to explore the major drivers of sea-ice and accuracy of prediction methods. ARCUS also organizes the Sea Ice for Walrus Outlook (SIWO) as a resource for Alaskan Native subsistence hunters and other interested stakeholders. This effort provides weekly reports, during April-June, of sea ice conditions relevant to walrus in the northern Bering and southern Chukchi seas. Collaboration among scientists, Alaskan Native sea-ice experts, and the Eskimo Walrus Commission is fundamental to this project’s success. The availability of short-term forecasts, such as SIO and SIWO, supports safety and productivity of local communities, scientists in the field, and marine operations in Alaska’s Bering, Chukchi, and Beaufort seas. With a different approach, PolarTREC (Teachers and Researchers Exploring and Collaborating) has been connecting U.S. teachers with polar researchers in field-based experiences for over a decade. Teachers have joined research cruises in Alaska as part of the Bering Ecosystem Study and the Hanna Shoal Ecosystem Study, changing how they teach and communicate science. These educators continue to use the Arctic as a core part of their classroom teaching, and maintain ongoing collaboration with researchers.

Chart the Arctic - 2015 Progress and Highlights

Amy Holman, Ashley Chappell, David Zezula, Tim Smith

Presenter: Tim Smith

Email: timothy.m.smith@noaa.gov

NOAA is working with its partners to update charts of the Arctic and enhance the safety of ever increasing vessel traffic travelling north of the Aleutians. This poster gives an overview of the work done in Kotzebue Sound, Nome Harbor, the USCG proposed shipping route through the Bering Strait, and elsewhere during the summer of 2015. Visit us and learn what was accomplished, where we will be going next, what data is available for marine scientists and how to get it.

Arctic - Humans

NOAA Ship *Fairweather* Arctic Exposition Projects - We Do More Than Surveys!

Amy Holman, David Zezula, Ryan Wartick, Matt Forney

Presenter: Amy Holman

Email: amy.holman@noaa.gov

NOAA hydrographic survey ships welcome space available projects on a not to interfere basis. In 2015 the NOAA ship *Fairweather* hosted eight collateral projects during their Arctic Expedition. The ship deployed an AOOS wave buoy in the Bering Strait; contributed data to the Distributed Biological Observatory with additional CTD casts; provided Marine Mammal observations; conducted plankton tows for HAB surveillance and to delineate the northern extent of the warm Blob; deployed a NAVOCEANO Glider and Profiling Float; retrieved PMEL's sail glider; and conducted a response survey in the Hog Island Channel for the USCG and Alaska Marine Pilots after the M/V *Fennica* struck an uncharted object. This poster provides highlights from the 2015 projects and the process for requesting space available on future cruises.

Changing Sea Ice, Marine Mammals, and Subsistence Hunters in Northern Alaska

Lori Quakenbush, Mark Nelson, Henry Huntington

Presenter: Henry Huntington

Email: hph@alaska.net

Marine mammals are important sources of food for indigenous residents of northern Alaska. Changing sea ice patterns affect the behavior of animals and thus the success of hunters. Documenting the traditional knowledge of Iñupiaq and Yup'ik hunters concerning marine mammals and sea ice makes a wide range of information and insight relevant to ecology, conservation, and human activity accessible. We interviewed hunters in villages from the northern Bering, Chukchi, and Beaufort seas about the movements and behaviors of bowhead whales, walruses, and ice seals (ringed, bearded, spotted, and ribbon seals). Information gathered through the interview process is combined with movements of animals from tracking data (i.e., satellite telemetry), from three different projects funded by the Bureau of Ocean Energy Management, to provide a more complete picture than either method would alone. Hunters reported extensive changes in sea ice, with resulting effects on the timing of migrations, the distribution and behavior of the animals, and the efficacy of certain hunting practices. For example, it has become increasingly difficult to find ice thick enough to support a bowhead whale for butchering and seal hunters must hunt earlier in the spring for seals due to a the rapid break-up and retreat of sea ice. While many changes are limiting, some expand opportunities; St. Lawrence Island can now hunt bowhead whales in winter as well as spring. Hunters acknowledged the positive changes of technological advances, such as more powerful and efficient outboard engines, that have increased their hunting range. Effects of changes, such as increased shipping traffic and oil and gas development are still largely unknown but have the potential to be negative. Continued environmental changes, increased disturbance from human activity, and how marine mammals respond to these changes will likely further challenge the ability of hunters to secure food for their communities. Iñupiaq and Yup'ik hunters, however, are well known for their innovation and flexibility, which may be tested while adjusting to the rapid changes.

The Fat's where it's At: New Approaches to Track Intact Phospholipids and Triacylglycerides in Euphausiids via Tandem LC-MS

Rachel Pleuthner, Rodger Harvey

Presenter: Rodger Harvey

Email: rharvey@odu.edu

In the eastern Bering Sea and Chukchi Sea, *Thysanoessa raschii* are the most abundant krill species and a keystone trophic component that serves as both an important grazer and a link to upper levels consumers including whales. In these waters, krill experience large variation in food resources during annual ice advance and retreat and store multiple lipid classes for both reproduction and growth. Two shipboard feeding experiments tested the lipid retention in adult *T. raschii* and examined the fluctuation of specific lipid biomarkers under food-limited conditions. Phospholipids represent the major structural lipid but also serve as energy storage and their retention as intact phospholipids (IPL), as well as other glycerides (i.e. diacyl- and triacylglycerides; DG and TG), were followed over 19- and 31-day experiments via tandem mass spectrometry (LC-MS). A complex suite of IPL's were observed and comprised the majority of intact lipids present, most of which had phosphatidylcholine (PC) headgroups; smaller contributions were made by phosphatidylethanolamine (PE) and phosphatidylserine (PS). The fatty acids present were largely represented by seven compounds – C14:0n, C16:0n, C16:1(n-7), C18:1(n-7), C18:1(n-9), C20:5(n-3), C22:6(n-3) and were arranged as mixed acyl groups within each intact lipid class. Concentrations over time (µmole/g wet weight) of IPL and glyceride lipids showed a decrease of 21% and 26%, respectively, suggesting that both are mobilized in times of food scarcity and during overwintering. Structures containing 16:1 decreased most for IPL's, reflecting the absence of the 16:1(n-7) dietary algal fatty acid. This more powerful set of analytical and software tools allows determination of the suite of intact lipids within euphausiids at unprecedented levels of detail to allow a comprehensive picture of krill structural and storage lipids and their retention during times of varied food availability.

Summer Survival Strategies of Sea-ice Associated Bacteria in the Chukchi Sea

Esty Willcox, Eric Collins

Presenter: Esty Willcox

Email: ewwillcox@alaska.edu

The Arctic Ocean is already experiencing changes under the influence of increasing temperatures. To better understand the ability of the ecosystem to adapt it is imperative that the seasonal cycle of microbial diversity is understood from an ecological perspective. In the marginal ice zone and in ocean areas where first year sea ice dominates, sea ice-associated bacteria are flushed into the water column once the ice melts. Once in the water column, their fate is unknown. Since bacteria play an important role in the cycling of nutrients, their 'oversummering' strategies may impact ecosystem dynamics in a warming Arctic. A first step in mapping this influence is to identify where sea-ice associated species dwell when not embedded in the ice. Samples for this study were collected as part of the Arctic Marine Biodiversity Observing Network (AMBON) in August 2015. Analyses will include deep sequencing of 16S rRNA barcodes to identify known sea-ice associated bacteria in potential summer and autumn niches, including seawater, sediment, and host-associated niches in the Chukchi Sea, a seasonally ice-covered Arctic sea.

Compound-Specific Isotopic Analyses of Amino Acids in Invertebrates of the Chukchi Sea: New Insights on Food Web Dynamics

Mengjie Zhang, Dana M. Biasatti, Monika Kedra, Lee W. Cooper, Jacqueline M. Grebmeier

Presenter: Mengjie Zhang

Email: mzhang@umces.edu

Food web dynamics in the Chukchi Sea have been previously evaluated using bulk analysis of stable carbon and nitrogen isotopes of organisms. However, recent advances in compound-specific stable isotope analysis of amino acids indicate the potential to better identify the contributions of different dietary sources (e.g., pelagic vs. benthic, ice algae vs. phytoplankton) and to resolve complexities of food web structure that are difficult to address with bulk isotope analysis. Here we combine amino acid $d^{13}C$ and $d^{15}N$ data measured from primary producers and tissues of bivalves, polychaetes and other benthic invertebrates collected during two cruises in the summer of 2013 and 2015 in the Pacific Arctic. The results showed spatial variation of carbon isotope values in amino acids with difference up to 6 per mil for each individual species or taxa studied, indicating a shift in the food-web baseline geographically. Furthermore, the spatial variation in isotopic values was related to environmental factors, specifically sea ice extent, and total organic carbon, total organic nitrogen and the carbon/nitrogen ratio of the organic fractions of surface sediments. Results also indicated that trophic levels, as estimated by differences in the nitrogen isotope composition of glutamic acid and phenylalanine [$D^{15}N_{glu\text{-}phe}$ ($d^{15}N_{glu} – d^{15}N_{phe}$)], varied spatially by 0.5 to 1.5 trophic level for certain species or taxa such as *Macoma calcarea*, *Maldanidae* and *Ampelisca*, indicating trophic level shifts that were associated with the food quality of organic matter in the organic fraction of the sediments. These results can be potentially used to predict future food web change in this high latitude marine system that is known for its ecological importance and on-going environmental changes, including warming and sea ice decline.

Contribution of Microbially Derived Carbon Sources to Arctic Benthic Food Webs

Ann-Christine Zinkann, Katrin Iken

Presenter: Ann-Christine Zinkann

Email: azinkann@alaska.edu

The Chukchi Sea shelf is a region of high productivity, strong pelagic-benthic coupling, and a rich benthic community. Rising temperatures and increased freshwater content as well as changes in seasonal ice primary production in the Chukchi Sea may have implications for the major carbon sources for the benthos and its associated food web. The contribution and importance of microbial processing of organic matter for the benthic food web still remains an open question, but may become increasingly important in light of these ecosystem changes. Fatty acid and compound specific stable isotope analyses are used as biochemical microbial markers to assess the presence of mircobes and their modification of organic matter within sediments. Further, we determine the reliance of various benthic feeding types on microbially derived carbon. This study contributes to the Arctic Marine Biodiversity Observing Network (AMBON) project by analyzing functional diversity in the Chukchi Sea food web.

Characterizing the Carbon Isotopic Composition of Dissolved Inorganic Carbon in Sea Ice Pore Water as a Carbon Source for Sea Ice Algae in the Arctic

Tanja Schollmeier, Katrin Iken, Matthew Wooller

Presenter: Tanja Schollmeier

Email: tschollmeier@alaska.edu

Sea ice algae in the Arctic are an important food source for benthic and pelagic organisms. Ice algae utilize the dissolved inorganic carbon (DIC) in brine channels of the sea ice matrix as carbon source during photosynthesis. The relatively closed system within the brine channels has been hypothesized to cause carbon limitation as a means of accounting for the high $\delta^{13}C$ values of ice algae that have been recorded in the Arctic, relative to open ocean phytoplankton. We provide the first empirical data documenting the stable carbon isotope composition of DIC from pore water taken from sea ice in the Arctic. We collected DIC and ice algal samples during the SUBICE project to the Chukchi Sea. The mean and max $\delta^{13}C$ values of DIC from sea ice pore water were higher, ~2‰ and ~5‰ respectively, compared with DIC in open water collected from directly underneath the ice. $\delta^{13}C$ DIC values generally decreased throughout the ice cores sampled, with increasing distance to the seawater interface, likely due to reduced ice algal production higher in the core. Corresponding ice algal samples were also measured for their $\delta^{13}C$ values, but no statistically significant correlation between DIC and ice algal $\delta^{13}C$ values was found. Additional factors that influence DIC and ice algal $\delta^{13}C$ values that are being investigated include ice porosity, snow cover, total hours of sunlight exposure at a site and ice thickness. Over the course of 15 days (Jun 3 – Jun 18) at the same ice floe, the $\delta^{13}C$ values of DIC and core temperature decreased for all ice core depths, likely linked to the opening of the brine channels to exchange with the underlying ocean water. Calculated brine salinity also decreased during the study period. Our research provides insight into the mechanisms leading to the relatively high $\delta^{13}C$ values in sea ice algae in the Arctic, which can be used to follow the fate of ice algae through the arctic food web.

Cold Year Crab Larvae in the Southern Chukchi Sea: Variation in Biogeographic Abundance Relative to Water Masses in 2012

Jared Weems, Alexei Pinchuk, Franz Mueter

Presenter: Jared Weems

Email: jdweems@alaska.edu

A significant knowledge gap exists in benthic species planktonic larvae ecology in the Arctic. Deficiencies include: lack of taxonomic and stage-specific resolution, unclear or under-reported abundance estimates, and potentially biased processing methods for rare or seasonally present species. This study provides preliminary abundance and distribution of seasonally present Anomura and Brachyura crab larvae from a recent cold year, 2012, in the U.S. southern Chukchi Sea. Using 505µm mesh 60cm Bongo zooplankton net samples, we compare non-subsampled larval abundance with concurrent pelagic environmental data and benthic adult crab distributions to attempt to discern larval advection processes into the Arctic. These results are the first of their kind in a region in which crab larval transport and settlement/recruitment to the benthos remains undescribed. If differential transport of larvae north into the Arctic through Bering Strait is water mass associated, segregation and settlement of the glaucothoe and megalopa stages could be species and time-specific, likely governed by larval origin and developmental rate, water flow, and available downstream nursery habitat.

Zooplankton Assemblages in an Arctic Estuarine Lagoon: Composition and Distribution in Relation to Local Hydrography

Alexei Pinchuk, Leandra Sousa, Johanna Vollenweider

Presenter: Alexei Pinchuk

Email: aipinchuk@alaska.edu

Lagoons play an important role in the Arctic ecosystem providing vital habitat for a variety of organisms including numerous anadromous and marine fishes. It is usually thought that in a typical Arctic lagoon most of the energy from both auto- and allochthonous primary producers is transferred to higher trophic levels through rich and diverse benthic biota. To investigate potential contribution of pelagic organisms to the food web, we assessed composition and distribution of zooplankton in the Elson Lagoon (Barrow, Alaska) and the adjacent nearshore region of the Beaufort Sea during summer in 2014-2015. Marine copepods and hydrozoan jellyfish occurred in modest quantities in the saltier (>26 PSU) well-mixed area of the lagoon near the passages between barrier islands. This zooplankton assemblage was similar to the one found in the neighboring Beaufort Sea, which indicates substantial water exchange in the lagoon system. In contrast, an abundant brackish-water (<20PSU) community dominated by copepod *Limnocalanus macrurus grimaldii* developed in the stratified waters far inside the lagoon in the vicinity of Chipp River mouth in July. These lipid-rich copepods are an excellent source of energy for euryhaline predators capable of tolerating low salinity, but, probably, are inaccessible to true marine species. The duration and success of the *Limnocalanus* production season may be important to survival and year-class strength of broad cisco (*Coregonus nasus*) juveniles, which perform ontogenetic migration from tundra lakes and rivers to estuarine nursery areas each summer after spawning.

Beaufort Sea Zooplankton Communities 2010-14 and Relation to Hydrography

Caitlin Smoot, Russell Hopcroft

Presenter: Caitlin Smoot

Email: casmoot@alaska.edu

Zooplankton are important trophic links, yet are poorly characterized in the Beaufort Sea. Epipelagic zooplankton were sampled along across-shelf transects from Point Barrow to the Mackenzie River during August and September from 2010-14 as part of an interdisciplinary effort to characterize the biology of the Beaufort Sea. Seven copepod taxa dominated community abundance and biomass during all surveys: *Calanus glacialis*, *Calanus hyperboreus*, *Metridia longa*, *Oithona similis*, *Triconia borealis*, *Microcalanus pygmaeus,* and *Pseudocalanus* spp. Despite the dominance of these seven taxa, distinct faunal groupings associated with hydrographic characteristics were identified. The western Beaufort exhibited highest abundances of Pacific-derived taxa (e.g., *Neocalanus* spp.), demonstrating the hydrographic connectivity between the subarctic Pacific, the Chukchi Sea, and the Beaufort Sea. In contrast, the central and eastern Beaufort were more traditionally Arctic in faunal character, with the influence of the Chukchi Sea and Pacific-derived waters increasingly weakened towards the Mackenzie River. The eastern Beaufort in the vicinity of the Mackenzie River hosted markedly different communities in 2013 and 2014, reflecting the different freshwater signals observed during each survey. In 2013 we observed a strong freshwater signal, which resulted in extreme across-shelf faunal gradients and a nearshore community characterized by cladocerans, rotifers, and euryhaline copepod species. In 2014 euryhaline taxa were largely absent, reflecting the weak freshwater signal during the survey. Our work demonstrates the influence of hydrographic features on zooplankton community composition, allows comparisons with historical datasets spanning over 60 years, and provides a contemporary benchmark for Beaufort Sea zooplankton communities from which future change may be assessed.

Microbial Community Composition in Beaufort Sea Sediments: Assessing Diversity and Environmental Drivers of Bacteria and Meiofauna

Alexis Walker, Sarah Hardy, Holly Bik, Jyotsna Sharma, Arny Blanchard

Presenter: Alexis Walker

Email: amwalker8@alaska.edu

An Arctic-wide decrease in sea ice extent over the past three decades has resulted in complex shifts in surface primary productivity, water temperature, and salinity. Additionally, recent climate fluctuations have resulted in the increased input of terrestrial organic matter (OM) from permafrost melt and coastal erosion. How will these large-scale shifts in OM input affect benthic communities? One way to address this complex question is to focus on micro-scale communities found in marine soft-sediment habitats, such as the Beaufort Sea shelf and slope, which are exposed to these types of influences. Sediment communities are ideally suited to tracking long-term change because they tend to dampen short-term seasonal or interannual “noise” in many environmental characteristics (e.g., primary production or hydrographic features). Additionally, benthic infauna, are widely used as indicators of disturbance impacts because they are relatively non-motile, reproduce rapidly, and respond relatively quickly to change. Bacteria and microscopic infauna also play key roles in biogeochemical cycling of organic matter in sediments. In order to examine micro-scale processes in Beaufort Sea sediments, 18S and 16S amplicon gene surveys were used to characterize bacterial and meiofaunal communities from the upper 1cm layer of sediments across varying water depths. Bacterial and meiofaunal community composition and diversity were also examined with respect to local biotic and abiotic variables including temperature, salinity, depth, latitude, longitude, chlorophyll-a, grain size, and stable isotope data. We will discuss bacterial and meiofaunal alpha and beta diversity, the metabolic strategies reflected in the taxonomic community composition, and the functional diversity of these communities with respect to environmental parameters. Characterizing assemblages and identifying drivers of community structure in benthic marine bacteria and meiofauna can allow us to monitor short and long-term changes in the functioning of this system, and contribute to understanding benthic food-web dynamics.

A Step toward Mapping Microbial Diversity in the Arctic via the Barents and Chukchi Seas

Brian Ulaski, Eric Collins

Presenter: Brian Ulaski

Email: bpulaski2@alaska.edu

Mapping the diversity of Arctic marine microbes is pertinent as a changing climate alters the environmental parameters of this sensitive environment. Sequence libraries of microorganisms from Arctic sympagic and pelagic environments will be analyzed via next-generation targeted-amplicon sequencing of 16S rRNA. Viral abundance and taxonomic diversity will also be identified using metagenomics. Alongside these molecular surveys, contributing environmental parameters will be assessed including temperature, salinity, depth, and nutrient concentrations. We will compare and contrast the effects of environmental and biological drivers on the diversity and spatial distribution of marine microbiota across the Barents and Chukchi Seas. A comparative study between these two seas will be beneficial to our understanding of how different sources of water masses to the Arctic Ocean shape microbial communities, as the Barents Sea is influenced by warmer Atlantic water relative to colder Pacific water entering the Chukchi Sea. Additionally, these two Arctic bodies of water both sit atop shallow continental shelves. The more we understand now about the structure of these microbial communities, the better we can predict and aptly approach the inevitable changes that our current Arctic Ocean will undergo.

Mesozooplankton of the Canadian Beaufort Sea - Distribution, Diversity and Ecological Importance for the Ecosystem

Wojciech Walkusz, Andrew Majewski, Jane Eert, James Reist

Presenter: Wojciech Walkusz

Email: wojciech.walkusz@dfo-mpo.gc.ca

During summer 2012, mesozooplankton samples were collected at 28 stations in the Canadian Beaufort Sea as part of the Beaufort Regional Environmental Assessment (BREA) Marine Fishes Project. Sampling was performed in a vertically stratified manner with a 150 um Multinet sampler and stations' depth spanned from 40 to 1000m. Also, oceanographic conditions, e.g. salinity/temperature, were recorded to provide data on the water mass distribution. Zooplankton biomass (per m^3) was greatest at shallower locations, particularly at deeper layers. We believe that this could be due to the avoidance of the warmer and fresher water by typical marine taxa, that are often brought to the inshore by upwelling events. We observed increased diversity of zooplankton further offshore, mainly due to the occurrence of the deep water taxa. There were seven taxa that made on average 90% of biomass at all stations; these were *C. glacialis*, *C. hyperboreus*, *Pseudocalanus* spp., *M. longa*, *P. glacialis*, Polychaeta larvae and *Oikopleura* spp.. Our project provided essential data on spatial and vertical distribution of mesozooplankton, which can serve as a baseline information for the purpose of environmental assessments and ecological modelling.

Assessing Hydrocarbon Sensitivity and Establishing Current CYP1A Baselines in Arctic Marine Birds and Waterfowl

Ann Riddle, Tuula Hollmen, Robert Suydam, Robert Sarren, Raphaela Stimmelmayr

Presenter: Ann Riddle

Email: annr@alaskasealife.org

With prospects of increasing development of oil and gas resources and commercial shipping in the Chukchi and Beaufort seas, establishing baselines and assessing sensitivity of Arctic wildlife to hydrocarbon exposure will provide essential information needed for management and conservation for species potentially impacted by an oil spill. Using a broad selection of marine birds and waterfowl, we are using species-specific cell culture to assess hydrocarbon sensitivity by measuring liver cytochrome P450 (CYP1A) activity using 7-ethoxyresorufin-*O*-deethylase (EROD). We have tested assay reagents (e.g. dimethyl sulfoxide) for non-specific toxicity and used positive control reference reagents (e.g., chrysene) to establish baseline responses for cell lines in ten bird species and a control species (mallard, *Anas platyrhunchos*). EROD responses and cellular cytopathic effects for each species were measured after a reagent dose exposure time of 24 hours. Results indicate differences in species response to control reagents. Additionally in 2015, cells from four Arctic species and mallard control were exposed to various amounts of Alaska North Slope crude oil to determine CYP1A activity in a compound mixture. Ongoing data analysis will evaluate cytopathic effects and the degree and duration of CYP1A induction to compare species sensitivity to reference reagents and crude oil. Additional work includes establishing baselines of current CYP1A activity in livers from three bird species of subsistence importance by validating field sample collection methods and using EROD. King eiders (*Somateria spectabilis)*, common eiders (*Somateria mollissima),* and greater white-fronted geese (*Anser albifrons)* were sampled near Barrow, Alaska during spring and fall hunts in 2014 and 2015. Cell culture sensitivity and liver baseline exposure results from this project will provide valuable tools and information for monitoring Arctic bird populations, identifying sensitive species, and future Natural Resources Damage Assessments in the event of an oil spill.

Lactating Northern Fur Seal Females Compromise on Foraging Efficiency or Pup Feeding Rates during the Breeding Season

Tiphaine Jeanniard-du-Dot, Andrew Trites, John Arnould, Christophe Guinet

Presenter: Tiphaine Jeanniard-du-Dot

Email: dudot@zoology.ubc.ca

Efficient extraction of energy from the environment is key to the survival and reproductive success of wild animals. Understanding the ratio of energy gained to energy spent of different foraging strategies (*i.e.*, foraging efficiency) can shed light on how animals cope with environmental changes and how it affects population trajectories. I investigated how female foraging strategies during the breeding season impact the foraging efficiencies and reproductive successes of northern fur seals breeding on St. Paul Island, Bering Sea. Twenty lactating females of each species were captured and equipped with biologging tags to record GPS locations, depth and tri-axial acceleration. Energy expenditure for each foraging trip was measured using the doubly-labeled water method, and energy gained while foraging was determined from 1) diet composition (scat hard-parts and DNA) and blood C and N stable isotope ratios; and 2) numbers of prey capture attempts (from head acceleration). Fur seal females employed two foraging strategies with very different efficiencies (~1.4 vs ~3.0) that were associated with different foraging habitats and diet qualities. Females with the most efficient strategy (3.0) have more energy overhead to allocate to their pups but they also undertook longer foraging trips than the other lower-efficiency group (1.4), and thus fed their pups ~25% less frequently. As a consequence, northern fur seal females from the declining population of St Paul Island had to compromise between the rate of energy acquisition or the frequency of pup feeding on land. Resulting reductions in energy intake or time allocated to nursing pups can ultimately lower survival of young-of-the-year which heavily rely on energy supplied by their mothers during the breeding season.

Severe Decline in Abundance on Steller Sea Lion Rookery at Medny Island (Commander Islands), Russia

Natasha Laskina, Vladimir Burkanov

Presenter: Natasha Laskina

Email: lask.natalia@gmail.com

Yugo-Vostochny rookery is the major breeding site of the Steller sea lion (SSL) in the Commander Islands located on the southern tip of Medny Island. Annual observations at rookery sites were carried out there since 1991. Surveys include regular counts of individuals by sex and age groups, pup births, and the animal mortalities on entire rookery (over 5 km long). Observations were carried out from the slope of the shore from fixed points located at a height of 25-30 meters above the SSLs using binoculars without disturbing the rookery. Count methods have remained unchanged throughout the 24 years of observation. In 2015, observations of the rookery were made daily from May 30 to August 7 by four researches. During pupping and mating periods (May 30 to July 10) a median 176 (q0=112, q0.25=151, q0.75=192, q1=203; *n*=14) non-pup individuals were present on rookery of which 115 (q0=50, q0.25=94, q0.75=126, q1=142; *n*=14) were females; 48 (q0=28, q0.25=44, q0.75=52, q1=53; *n*=14) were mature males, and 6 (q0=2, q0.25=5, q0.75=7, q1=10; *n*=14) were juveniles. A total of 153 pups were born at the rookery and fourteen of them were born dead or died soon after the birth (9.2%). There were no cases of death of individuals 1+ years old observed. The number of all age and sex groups declined compared to the same period of 2014. The number of 1+ years old animals decreased by 28%, females by 27%, pups by 6%. Pup production at this rookery reduced by 35% over the past 10 years (2006-2015), or -4.6% annually. The maximum number of pups born on Medny Island was recorded in 1998. Over the past 17 years the pup number declined by 45%. The non-pup abundance decreased by 72%, while the number of females decreased by 66%. Declines are caused by the low survival rates, reduced birth rates and dispersal of young mature females to other breeding locations.

Pacific Walrus Bone Steroid Hormone Levels Over the Past 3,600 Years

Patrick Charapata, Lara Horstmann, Nicole Misarti

Presenter: Patrick Charapata

Email: pmcharapata@alaska.edu

The Pacific walrus (*Odobenus rosmarus divergens*) is an iconic Arctic marine mammal that Alaskan Natives rely on as a food, economic, and cultural resource. A decrease in critical sea ice habitat and unknown population numbers have led to walruses being listed as a candidate for the Endangered Species Act, but there is no clear understanding of how walruses might be affected by climate change. In this study, steroid hormone concentrations (e.g., progesterone, testosterone, estradiol, and cortisol) from walrus bone collected over the past 3,600 years were analyzed to track potential fecundity and stress response changes throughout current and past climate warming events. Cortical bone preserves for thousands of years, has a low turnover rate (~3%/year), and contains lipophilic steroid hormones. Bone thus has the advantage of capturing an average life-long steroid hormone signal of an individual. Progesterone and estradiol were the primary factors contributing to significant differences among decades. Mean progesterone concentrations ranged from 783 (ng/g) in 2010s to 29,644 (ng/g) in 1960s. Mean estradiol concentrations ranged from 2,403 (ng/g) in 2010s to 6,148 (ng/g) in 1970s. Hormone concentrations in archeological walrus bones were similar to mean historical concentrations from various other decades. High progesterone and estradiol levels in the 1960s and 1970s correlate to a rapid increase in the walrus population during this period and may be indicative of high fecundity and calf production. Relatively low progesterone and estradiol concentrations in the current decade correspond to low fecundity and calf production that has been described throughout the recent literature and hunter observations from St. Lawrence Island, AK. Cortisol concentrations, an indicator of stress response, have not changed through the time periods covered by our samples, suggesting overall flexibility to changing ecosystem dynamics. Our results give insight into past physiological resiliency of walruses and provide a new tool to track steroid hormone concentrations of marine mammals through time. Specifically, female reproductive hormones including progesterone and estradiol may prove to be a powerful walrus population monitoring and management tool.

Assessing Abundance of Beluga Whales in Bristol Bay Using Genetic Mark-recapture Methods

John Citta, Lori Quakenbush, Greg O'Corry-Crowe, Roderick Hobbs, Myra Olsen, Tatiana Ferrer

Presenter: John Citta

Email: john.citta@alaska.gov

The Bristol Bay stock of beluga whales is one of five stocks commonly recognized in Alaskan waters. Bristol Bay belugas are genetically distinct from other stocks and tagging studies show they reside in Bristol Bay year-round. Bristol Bay belugas are harvested by Alaska Natives and periodic assessments of population abundance and trend are necessary for harvest management and population conservation. When last surveyed, this stock appeared to be increasing; aerial counts of belugas in Bristol Bay increased by 4.8% per year between 1993 and 2005 and are believed to number ~3000 animals. However, counts from aerial surveys must be adjusted to correct for sightability and availability bias. As examples, while mature belugas are white and readily visible when at the surface, young whales are gray and easily missed (i.e., sightability bias). Also, only whales at the surface are available to be counted in the silty water found in the bays (i.e., availability bias). Typically, correction factors are applied to aerial survey data to adjust the count for the number of belugas that are missed or unavailable for counting. Unfortunately, such correction factors do not currently exist for Bristol Bay. An alternative technique for estimating abundance of belugas involves collecting skin samples for genetic identification. In effect, molecular markers are used to genetically identify individual belugas and repeated sampling allows us to analyze genetic “recaptures” within a mark-recapture framework. We proposed to use genetic mark-recapture to estimate abundance and then use the mark-recapture estimate to develop a correction factor for aerial surveys. The Alaska Beluga Whale Committee and the Bristol Bay Native Association, Marine Mammal Council chose Bristol Bay as an ideal site for application of genetic mark-recapture methods because aerial surveys and tagging studies are conducted in Bristol Bay periodically. Between 2002 and 2011, we have identified 539 unique belugas in Bristol Bay. We are currently in the process of genotyping and matching 236 remaining samples, collected between 2011 and 2014. We expect project completion by January 2017.

Vibrissae Growth in Two North Pacific Pinnipeds: Implications for Determining Foraging Behavior from Stable Isotope Analysis

Skyla Walcott, Elizabeth McHuron, Jenifer Zeligs, Stefani Skrovan, Dan Costa, Colleen Reichmuth

Presenter: Skyla Walcott

Email: skyla.walcott@gmail.com

Stable isotope analysis of vibrissae can provide a temporal record of foraging behavior, and can be used to measure individual behavior over relatively long time periods. Despite increasing use of this method, an understanding of vibrissal growth dynamics are lacking for most species, yet are necessary for appropriate study design and interpretation of isotope data. Here we present measurements of vibrissae growth in two spotted seals (*Phoca largha*) and five California sea lions (*Zalophus californianus*) using photogrammetry. Data were collected from trained, captive animals for one year, resulting in serial measurements of 153 spotted seal and 321 sea lion vibrissae. Spotted seal vibrissae exhibited an asymptotic growth pattern, with initial growth rates ranging from 0.11 to 1.40 mm/day. On average, it took vibrissae 48 and 105 days to reach 75% and 95% of their asymptotic length, respectively. In contrast, vibrissae of California sea lions grew at a linear rate that varied depending on the length of the individual vibrissa. Growth rates ranged from 0.002 to 0.180 mm/day and were faster for longer vibrissae (r^2= 0.36, $p < 0.001$). Over 50% of spotted seal vibrissae were lost during their annual pelage molt, whereas California sea lion vibrissae loss was 3%, with no clear temporal pattern. The contrasting growth patterns observed for these two species are consistent with previous studies that showed non-linear growth in phocids and linear growth in otariids. Our results indicate that foraging information contained within spotted seal vibrissae primarily represent the months leading up to and following the annual pelage molt. In contrast, the vibrissae of California sea lions can be used to assess long-term foraging behavior, but length-dependent growth rates should be considered when ageing individual vibrissa. Overall, these data have important implications for study design and interpretation of stable isotope values to assess foraging behavior of pinnipeds.

Harbor Seal Biosampling: Revitalizing a Partnership with Traditional Alaska Native Subsistence Hunters to Monitor Health, Diet, and Stress of Seals in the Aleutians

Amanda Bishop, Eric Bortz, Joni Bryant, Jennifer Burns, Bernadine Erickson, Anne Hoover-Miller

Presenter: Amanda Bishop

Email: ambishop2@uaa.alaska.edu

Harbor seals (*Phoca vitulina richardsii*) are among the most commonly observed marine mammal along the Alaska coastline, and are an important resource for Alaska Natives who rely on them for food, spiritual, and cultural sustenance. Harbor seal populations have undergone dynamic changes in abundance in the past three decades; of particular concern are factors affecting populations in the Aleutian Islands, where seals declined by 67% in the 1970s and have not shown signs of recovery. Obtaining biological samples from across the breadth of a species' range is essential for investigating causal links to regional declines, but also allows for monitoring effects of climate change, assessing health and condition of seals, and ensuring seals are safe food sources for Native communities. The Alaska Native Harbor Seal Commission (ANHSC) Biosampling program has previously developed co-operative networks of certified biosampling technicians to obtain tissue samples from subsistence harvested harbor seals for scientific research. This project marks the revitalization of the harbor seal biosampling program, with effort focused on seals in the Aleutian Islands. Emphasis will be placed on engaging participation from community members, two-way exchange of local traditional knowledge and scientific findings, and the development of an online biosampling training and certification module. Scientific research from the collected samples will be used to investigate the effects of climate change, assess the health and condition of seals and assure food safety and security for Alaskan Natives. Specifically, pathogen detection by qPCR and serological surveillance will enable understanding of regional variations in harbor seal disease exposure, and will help identify risks to human health from subsistence harvesting. The revitalization of the harbor seal biosampling co-operative network will thus provide benefits to the health and resistance of coastal communities, wildlife management, and will establish a framework for understanding, predicting, and mitigating the long-term effects of environmental perturbations.

Regional Variations and Drivers of Mercury and Selenium Concentrations in Steller Sea Lions

Lorrie Rea, J. Margaret Castellini, Lucero Correa, Brian Fadely, Vladimir Burkanov, Michael Rehberg, Todd O'Hara

Presenter: Lorrie Rea

Email: ldrea@alaska.edu

One factor for lack of recovery of endangered Steller sea lions (SSL, *Eumetopias jubatus*) in Alaska may be low natality. Mercury exposure can be neurotoxic to piscivorous mammals and impact reproduction. We measured total mercury concentration ([THg]) in lanugo (pelage grown *in utero*) of 655 SSL pups to assess fetal exposure during late gestation. We measured the molar ratio of total selenium to THg concentrations ([TSe:THg]) in whole blood collected from 135 pups to assess Se availability to potentially provide protection from the adverse effects of Hg. Finally we measured stable isotope ratios in sections of vibrissae (whiskers) of 170 young pups grown during late gestation to track diet variations between adult females that likely impact Hg exposure during this critical fetal development period.

Lanugo [THg] ranged from 0.6 to 73.7 μg/g dw with the lowest median [THg] in Southeast Alaska (SEA; K-W ANOVA $p<0.0001$, $Z>1.96$). Median [THg] was higher in the western and central Aleutian Islands (WAI and CAI) than in Russia, the eastern Aleutian Islands (EAI) and western Gulf of Alaska (WGOA) ($p<0.0001$, $Z>2.81$). In the WAI approximately 20% of pups had [THg] above published risk thresholds for other mammals, compared to 6.6% of pups in CAI, and 1% of pups in EAI. Whole blood molar [TSe:THg] was significantly lower in the WAI and CAI (minimum 2.0 and 1.9, respectively) compared to the EAI and WGOA (minimum 7.4 and 9.3, respectively) suggesting there may be a limitation on the potential protective function of Se in these regions with the highest [THg]. Pups born with the highest [THg] in their lanugo (above 30 μg/g) showed significantly higher $\delta^{15}N$ in vibrissa sections grown during late gestation ($p=0.0018$, $Z>1.96$) suggesting their mothers may have incorporated higher trophic level fish into their diet.

Mating Systems in an Endangered Species: Polygyny and Mate Choice in the Steller Sea Lion

Greg O'Corry-Crowe, Tom Gelatt, John Maniscalco, Michael Rehberg, Vladimir Burkanov

Presenter: Greg O'Corry-Crowe

Email: gocorryc@fau.edu

Polygyny creates unique challenges for species management, especially when modeling recovery of endangered species. Extreme skew in reproductive success of one sex reduces effective population size and can have substantial influences on micro-evolutionary processes that directly influence population viability and species resilience. The Steller sea lion is a polygynous species where relatively few adult males appear to successfully compete for access to breeding females. Extensive research on this species over the past four decades has been directed at understanding causes of population decline and failure to recover. Much of this research has focused on assessments of female reproductive success. We still understand little about male reproductive success, or about mate choice in either sex. This is largely due to a lack of genetic analyses needed to test hypotheses about mating v. reproductive success. Territorial polygyny, where the largest males attain dominance and thus access to most females, predicts that dominant males sire the majority of pups. However, there is very little genetic data to support or reject this model. Low mate fidelity by females can reduce reproductive skew. Furthermore, it may be adaptive for sexually mature but subordinate males to cheat. We used molecular genetics to investigate Steller sea lion mating systems. We sampled 2,356 pups at several rookeries across the species range to determine what factors influence mating systems, if these factors differ across populations and regions, and if so, why. Multi-locus genotyping was combined with direct observations of sea lion behavior. We developed a statistical method, 'kin-distance' to track the spatial and temporal distribution of full-sibs and half-sibs and found: (1) male reproductive success varies widely both within and across rookeries, and (2) some adult males successively bred with females on different rookeries. There is also some evidence of low population-level mate fidelity. Male and female Steller sea lions appear to employ a series of mating strategies to optimize fitness that include: mate switching despite potentially high site fidelity, breeding dispersal among rookeries and alternative strategies among males to territorial polygyny. All these behaviors can be parameterized for inclusion in more informative models of population viability and recovery.

Steak for Breakfast and Calamari for Dinner – Does a Balanced Diet for Killer Whales Mean a Predator Pit for Steller Sea Lions?

Paul R. Wade, John W. Durban, Russel D. Andrews, Tom Gelatt

Presenter: Paul R. Wade

Email: paul.wade@noaa.gov

Predation by Bigg's ("transient") killer whales has been proposed as one explanation for the continued decline of Steller sea lions in the western and central Aleutian Islands. There are relatively few reports of killer whale predation on marine mammals in this remote region; these include Dall's porpoise, Cuvier's beaked whale, sea otter, and one Steller sea lion pup. However, an acoustic recorder at a rookery on Agattu Island documented frequent (1 out of every 3 days) occurrence of Bigg's killer whales, suggesting predation of Steller sea lions may occur regularly. On the other hand, several lines of evidence (observed predation, low nitrogen stable isotope ratios, and some satellite tagging movements) suggest Bigg's killer whales may also prey on squid. In June 2015, we deployed 3 satellite-linked dive tags on Bigg's killer whales in the central Aleutians (2 in Rat Island Pass east of Kiska Island, and 1 at Tag Island in the Delarof Islands) to investigate their foraging behavior. Two of the whales showed repetitive diving to depths of 200-300m on a nearly daily basis, with diurnal patterns to dive depths, consistent with foraging on squid. The third whale did not transmit much dive data, but also showed one bout of repeated dives to 350m, so all three whales showed some evidence of deep diving behavior. Additionally, two of the whales also spent considerable time at shallow depths around Steller sea lion rookeries; over 17 days one whale occurred nearly every morning close to one of either two Steller sea lion rookeries in the Delarof Islands (Tag or Gramp). Intriguingly, this same whale switched to repetitive deep-diving behavior in deeper water nearly every evening and night. This suggests that at least some Bigg's killer whales may be foraging extensively on Steller sea lions, but also that the killer whale population may also forage substantially on squid. If so, this raises the question of a "predator pit" – does the availability of squid sustain Bigg's killer whales at abundance that is high enough that occasional predation is sufficient to prevent the recovery of Steller sea lions?

First Evaluation of Effect of Longline Fisheries on the Steller Sea Lion in the Russian Part of the Bering Sea

Sergey Fomin, Yuriy Artukhin, Andrey Testin, Olga Belonovich, Vladimir Burkanov

Presenter: Sergey Fomin

Email: kalan_87@mail.ru

Steller sea lions (SSL) have declined by 99% in the western part of the Bering Sea. Fisheries effects on the SSL population is one possible reason for the population decline. We investigate the possible effect of longline fisheries on the SSL mortality interviewing fishermen and surveyed SSL-fishery interactions while working on boats. Only 12 fishermen from total 112 interviewed participate in longline fisheries and all of them (100%) confirmed that SSL sometimes depredate in longline fishery. To protect the catch from SSL depredation ten respondents (83%) used guns and firecrackers to deter SSL. Observers were present during the fishery for a total of 199 days at sea in the Western Bering Sea in 2003-2004 (November-Janary), 2008 (July-October), 2010 (July -October) and 2013 (July-August). SSLs were observed near the fishing vessels only 9 times: 7 in Karaginsky Gulf (one encounter in 2004 and six encounters in 2008) and 2 in Gulf of Anadyr. SSLs were seen in late fall or winter in Karaginsky Gulf in a groups of up to 10 animals and two single individuals in summer 2013 at Gulf of Anadyr. SSLs were consuming fish from the longlines or foraged on fishery waste near vessels for a time period that ranged from 5 minutes to 2 hours. In 2013 crew tried to haze SSLs using gun, but SSLs moved farther from the vessel and continued foraging. The direct observation of longline fisheries in the western Bering Sea demonstrates that SSLs rarely approach the longline vessels. Probably, the SSL -longline fishery interactions occurs mostly in Karaginsky Gulf, where there fishery conducted mostly during winter. Number of injured and killed SSLs during the longline fishery in the western Bering Sea is probably low.

Alarming Results of the 2015 Steller Sea Lion Survey in Three Russian Far East Regions

Vladimir Burkanov, Natasha Laskina, Evgeny Mamaev, Viktor Nikulin, Sergey Phomin, Sergey Ryazanov, Andrey Tretyakov, Ivan Usatov, Vladimir Vertyankin

Presenter: Vladimir Burkanov

Email: vladimir.burkanov@noaa.gov

Steller sea lion (SSL) abundance has stabilized at a low level or is slightly increasing in most regions of Alaska and Russia except the western part of the Aleutian chain. SSL continue to decline in the Commander (CI) and Near Islands (Western Aleutian Islands). In late June-early July 2015 we surveyed SSL rookeries and haulouts in the Russian part of the Western Bering Sea (WBS), Eastern Kamchatka (EK) and CI. Survey methods were similar to previous years. Depending on location, topography of the site, and the number of SSL present, researchers photographed and counted animals from the main boat, small skiff, or from shore locations high above the SSL. SSL were counted by age and sex group using binoculars. Digital photographs were used whenever possible to confirm visual counts. Forty-four SSL sites are known in the survey area. We visited 34 (77%) sites on which SSL were present sometime in the last 20-25 years. SSL were found on 18 (53%) surveyed sites. In the WBS SSL were hauled out at four (33%) locations, and the non-pup count was 89. In CI SSL were present at six (60%) sites where we counted 490 non-pups. At EK SSL used 8 (67%) sites and non-pup number there was 526. Pups were found at only six sites; four in CI and two in EK. Throughout all three survey areas we counted 1,105 non-pups, 242 live pups, and 11 dead pups. No dead non-pups were seen. Compared with the previous survey in 2010, total non-pup abundance at trend sites slightly increased (6%) while the pup number decreased by 24% in both EK and CI. Non-pup trends were different in all three areas, increasing by 56% in the WBS and 10% in EK, but decreasing by 3% at CI. The ten-year trend (2006-2015) was clearly negative in all three survey regions and for all SSL age and sex groups. The strong pup decline suggests that the negative abundance trend will continue in the near future. The large difference in pup and non-pup trends suggests that low natality is driving the decline.

Preliminary Results of Ice-associated Seal Survey in Spring 2013 in Karaginsky Gulf, Bering Sea

Vladimir Chernook, Alexey Grachev, Irina Trukhanova, Aleksandr Vasiliev, Vladimir Burkanov, Boris Solovyev, Denis Litovka, Sergey Zagrebel'ny

Presenter: Irina Trukhanova

Email: irinatr@uw.edu

In collaboration with American scientists (Bering-Okhotsk-Seal-Survey, BOSS) two instrumental aerial surveys focusing on ringed, bearded, spotted and ribbon seal species were carried out in Karaginsky Gulf in April, 2013. An aircraft AN-38 “Vostok” equipped with IR-scanner, digital cameras and a computer system for data recording flew randomly positioned line transects. The survey area was divided into sampling units 12.5x12.5 km. Negative binomial GLMs with ice concentration, distance to ice edge and to 200 m isobaths as linear predictors were used to obtain basking population estimates for ice covered area of Karaginsky Gulf.

On April 11th, a survey was conducted during pupping season. A total 816 km of transects covered 341 sq km of ice. IR-scanner recorded 777 seals of which 81% were photographed. Mean observed seal density on ice was 2.28 individuals/sq km. Total seal number on ice (without accounting for animals in the water) in Karagisky Gulf was estimated 98,643 (CI95% 62,287-162,999) individuals. Species composition estimated based on randomly selected 629 digital photographs and was as follows: ringed - 46%, spotted - 37%, bearded - 6%, ribbon - 0.6%. Twenty four percent of ringed and 34% of spotted seals were identified as pups.

On April 30th, a survey was conducted during late reproduction/early molting season. A total 975 km of transects covered 426 sq km of ice on which 1055 seals were recorded by IR-scanner, and 61% of them were photographed. Mean observed seal density on ice was 2.41 individuals/sq km. Calculated seal number on ice in Karaginsky Gulf was 89,101 (CI95% 58,897-158,699) individuals without accounting for animals in the water. Species composition determined based on randomly selected 646 digital photographs was as follows: ringed - 24%, spotted - 37%, bearded - 24%, ribbon - 4%. Pups comprised less than 1% of all seals.

As a result of data processing, a database is being built and each detected seal will be assigned an individual number, information on seal species, its geographical coordinates, detection time and date, associated IR file and visual image names.

The work has been funded from AB133F10CN0355 grant of National Marine Fisheries Service, NOAA, USA.

Comparing Observed Population Trends with Modeled Population Projections Based on Direct Measurements of Survival and Birth Rates in Different Parts of Steller Sea Lion Range in the Russian Far East

Alexey Altukhov, Russel Andrews, Donald Calkins, Thomas Gelatt, Eliezer Gurarie, Thomas Loughlin, Evgeny Mamaev, Victor Nikulin, Peter Permyakov, Sergey Ryazanov, Vladimir Vertyankin, Vladimir Burkanov

Presenter: Alexey Altukhov

Email: aaltukhov@gmail.com

A full understanding of the decline of Western stock Steller sea lions over the latter part of the 20th century has eluded researchers, partly because direct estimates of mortality and fecundity are not available for most parts of their range, especially in the early period of decline. Censuses were conducted at many rookeries, but using count data to predict vital rates is challenging. To address this problem, we utilized a dataset of 4,765 sea lions branded on six rookeries between 1989 - 2008, and resighted from 2002 – 2011. Using mark-recapture, we estimated survival and birth rates up to 30 years of age and constructed a Leslie matrix population model to predict trends in the population for comparison with our visual counts of Steller sea lions in three regions of Far Eastern Russia. Survival and fecundity at the Commander Islands, the only area where the population continued to decline throughout the study period, were the lowest among all rookeries in Russia. Kozlov Cape, along the Kamchatka Peninsula, also had low birth rates compared with the Kuril Islands rookeries. High survival of adults at Kozlov Cape was the likely cause of the growing population trend there from the beginning of the 2000's. However, our model assumed a stable age structure, while the population at Kozlov Cape is the smallest of all rookeries, and the population there dropped significantly in the decade before it started to increase. The Leslie projection model predicted positive growth for all Kurils rookeries, confirmed by increasing pup counts there. Predicted survival and fecundity rates were consistent with observed pup counts at all rookeries in Russian Far East. The Commanders population decline during the past decade was likely related not only to lower adult survival, but also lower birth rates. However, non-pup counts were typically half the predicted values. This difference was greater at Kurils rookeries than on the Commanders and Kozlov Cape, probably because of inter-site variability in detection probability. Census data are clearly affected by factors that can vary throughout the range, not to mention by undocumented migration levels, thereby complicating their use to predict vital rates.

Postpartum Period in the Steller Sea Lions of the Commander Islands: The Connection with Decline in Natality

Sergey Ryazanov, Vladimir Burkanov

Presenter: Sergey Ryazanov

Email: ryazanovssl@ya.ru

The Commander Islands are located at the western part of the Aleutian Island chain, and are inhabited by a small subpopulation of Steller sea lion (SSL) belonging to the western stock. In contrast to the severe population decline of western stock SSL in Alaska during the late 20th Century, pup production at the Commander Islands increased until 1998. Several subsequent sharp drops in pup numbers led to a negative abundance trend, likely due to irregular female reproduction. We suggest this decline occurred due to decreased quality of habitat at the Commander Islands and SSL female wintering grounds. The duration of postpartum period (PPP) in SSL is considered to reflect environmental conditions where females foraged during the previous winter. We measured PPPs at Medny Island during 2009-2012 and 2014 and compared these with published data. We also analyzed the effects of year, birth date, female age, maternal experience, pup sex and all paired combinations of these predictors using generalized liner models. In 2009-2014 PPP varied from 4-16 (median=10.44, IQR=7.19-11.91) days and was significantly shorter than PPPs from published data for 2005-2007 ($p<0.001$). PPP varied significantly only with female age and the combination of female age and pup sex. Young females (4-6 y.o.) had shorter PPP in comparison with older females (>6 y.o.), explainable by their relative inexperience affecting seasonal increase in body condition. Young females nursing male-pups had shorter PPP than all others, perhaps driven by higher energetic demands of male-pups. However, this could also be an artifact of small samples of young females with known pup sexes (n=14). Decrease in natality and PPP in the last decade were probably driven by the same factors. The female adaptation mechanism to worsening environmental conditions during winter is obscure, but is somehow connected with decreased natality. This could be due to a decrease in hormone stimulation such that females reduce or skip copulation (we observed reduced numbers of copulations in seasons preceding sharp drops in pup production), embryo resorption or abortion during winter, or a combination of all these factors.

Monitoring the Small and Remote Population of Harbor Seals on Otter Island in the Pribilofs

David Withrow, Lauri Jemison

Presenter: David Withrow

Email: dave.withrow@noaa.gov

The Pribilof Islands stock of harbor seals, the smallest of 12 stocks in Alaska, includes seals from St. Paul, St. George, Walrus, and Otter Islands, with Otter comprising the largest segment. Due to its small size and isolation, this stock has not been regularly surveyed. Daily counts were first conducted during the pupping season on Otter Island in 1974. At that time, more than 1,250 harbor seals utilized the island, and were the predominant marine mammal species. From 1974 to 1978, harbor seal numbers on the island declined by about 40%. The decline continued and by 1995, numbers were reduced by 83% over the 21-year period, based on maximum counts. Conversely, northern fur seal, *Callorhinus ursinus*, numbers increased from fewer than 10 animals in 1974 to 1,774 in 1995 and are even higher now. By 1995, the maximal count of harbor seals was only 202 non-pups and 42 pups. Seven dead pups were found that year with trampling by fur seals indicated as the likely cause. Fifteen years later we surveyed the island again on July 16, 2010. From shore we observed 185 non-pups and 27 pups. We returned this year on July 18, 2015. Unfortunately, some seals entered the water before we were able to land our skiff on shore. We counted 98 non-pups (both hauled out and in the water) along with 13 pups. Undisturbed and repeated counts over several days are needed to understand daily variability and to determine whether the number of harbor seals using Otter Island has stabilized at a lower level, or continues to decline. After our ground counts were performed, we examined the seal's reaction to a small unmanned aerial system (UAS; drone) which flew along shore at various altitudes. In the test area, no animal reaction to the UAS was observed and the aerial count (23 seals) was higher than the number detected by shore observers (19 seals) suggesting the UAS could be a valuable tool for monitoring harbor seals in this population.

Harbor Seal (*Phoca vitulina*) Movement, Diving, and Haul-out Behaviors near Adak Island, Alaska

Shawn Dahle, Josh London, Peter Boveng

Presenter: Shawn Dahle

Email: shawn.dahle@noaa.gov

Harbor seal (*Phoca vitulina*) counts in the Aleutian Islands declined by about 67% during the 1980s and 1990s. While considerable efforts have been made to understand similar declines of Steller sea lions (*Eumetopias jubatus*) and northern sea otters (*Enhydra lutris kenyoni*) in the Aleutian Islands, no similar research has been conducted on harbor seals.

In this study, we used satellite-linked telemetry tags to collect the first data on harbor seal movement, diving, and haul-out behaviors in the Aleutian Islands. We captured 15 seals in Clam Lagoon on Adak Island, Alaska during September 2-9, 2014. Satellite tags were attached to each seal's head and/or hind flipper depending on its size and pelage molt status. Head tags (N = 13), which record movement, dive, and haul-out data, transmitted for an average of 207 days (Range: 166-237). Flipper tags (N = 12), which record location and haul-out data, transmitted for an average of 190 days (Range: 16-371).

Most seals' movements were quite limited throughout fall and winter, with 10 of 13 seals remaining within 25 km of Clam Lagoon and two more remaining within 50 km. Only 1 seal was more wide-ranging, traveling up to 207 km from Clam Lagoon, including trips off the continental shelf into the Bering Sea. The seals primarily foraged at two depth ranges: 0-30 m in or near Clam Lagoon and 80-140 m in nearby Sitkin Sound. Most seals reduced their haul-out duration in late September, marking a transition from their annual molt cycle to a period of increased foraging at sea. Haul-out duration increased again in mid-February and switched from a nighttime to daytime diel pattern. These data provide an initial view of the spatial use, foraging behavior, and time budgets of this reduced and poorly documented population. Additional tagging studies are being conducted in the eastern and western Aleutian Islands in 2015 and 2016, respectively, to expand the spatial and temporal range of our dataset.

Fur Seal Foraging Behavior Reflects Prey Stock Structure, Abundance, and Responses to Variable Oceanography and Storms

Jeremy Sterling, Mike Goebel, Sara Iverson, Noel Pelland, Rolf Ream, Alan Springer

Presenter: Jeremy Sterling

Email: Jeremy.Sterling@noaa.gov

Climate models predict increasing Bering Sea temperatures and declines in recruitment of walleye pollock. Predicting the impact on the northern fur seal, a species heavily reliant on pollock for food, requires the need for multiyear observational data linking climate, pollock, and fur seal foraging to help inform numerical ecosystem models, which is the goal of this study. Two northern fur seal studies conducted on the Pribilof Islands during the breeding seasons of 1995 and 1996 and 2005 and 2006 set out to better understand how the biophysical environment affects northern fur seal foraging success. These two studies focused on 136 adult females provisioning dependent pups and recorded 83,136 hours and 595,236 dives during 502 foraging trips to sea. Oceanographically, 1995 and 2006 were similar with respect to below average Bering Sea shelf bottom water temperatures and extensive cold pools. In contrast, 1996 and 2005 were oceanographically warm with much smaller cold pools residing farther to the NE and out of fur seal foraging range. In all years, available prey for fur seals differed demographically and spatially, resulting in fur seal behavioral responses that tracked the known age-related behavior, distribution, and abundance of walleye pollock and the variable cold pool occupancy of Pacific herring. Approximately 40% of fur seal dives occurred in the Bering Sea basin, a region dominated by mesoscale variability. Basin eddy identification and edge determination helped explain fur seal movement and dive behavior as well as interannual variability in basin occupancy. Eddy edges, type, and alignment within fur seal foraging habitat were all important factors. In 2005 and 2006, storms altered fur seal foraging behavior, causing seals in the basin to seek foraging opportunities on the shelf or deeper into the basin, while shelf foraging hotspots were abandoned, resulting in longer trips to sea. The results of this study show the interrelationships between the northern fur seal foraging behavior, variable prey fields, and climate states but lacks determinants of fur seal foraging success. Future work seeks to identify success to aid ongoing Bering Sea ecosystem modeling efforts.

Adult Reproductive Rates are Unlikely to be a Factor in the Recent Decline of Pribilof Fur Seals

J. Ward Testa, Rolf R. Ream, Thomas S. Gelatt

Presenter: J. Ward Testa

Email: ward.testa@noaa.gov

Pup production of northern fur seals on the Pribilof Islands, Alaska, began a significant decline sometime in the mid 1990's, with the decline slowing in 2004 on St. George Island, and 2010 on St. Paul Island. We present recent estimates of adult reproduction from marked populations at two rookeries on St. Paul and St. George Islands beginning in 2008 and 2010, respectively. We compare these to historic estimates prior to the decline of fur seals in the 1970's and 80's, and to rates theoretically necessary to produce recent rates of decline, either alone or in concert with changes in survival. We conclude that recent rates of adult reproduction are high and unlikely to be a contributing factor in the most recent population decline.

Satellite Tagging, Remote Sensing, and Autonomous Vehicles Reveal Interactions between Foraging and Migration Behaviors of a Top Marine Predator and the Environment in the North Pacific Ocean

Noel Pelland, Jeremy Sterling, Alan Springer, Sara Iverson, Devin Johnson, Mary-Anne Lea, Nicholas Bond, Rolf Ream, Craig Lee, Charles Eriksen

Presenter: Noel Pelland

Email: noel.pelland@noaa.gov

Behavioral responses by top marine predators to oceanographic features such as eddies, river plumes, storms, and coastal topography suggest that biophysical interactions in these zones affect predators' prey, foraging behaviors, and potentially fitness. However, examining these pathways is challenged by the obstacles inherent in obtaining simultaneous observations of surface and subsurface environmental fields and predator behavior. This work describes recent publications and ongoing studies of northern fur seal (NFS) foraging ecology during their 8-month migration. Satellite-tracked movement and dive behavior in the North Pacific Ocean was compared to remotely sensed data, atmospheric reanalysis, autonomous in situ ocean sampling, and animal borne temperature and salinity data. Integration of these data demonstrates how age, sex, size, and environment shape NFS migratory patterns.

Seal mass correlates with dive ability and thus larger males exploit prey aggregating at the base of the winter mixed-layer depth in the Bering Sea and interior northern North Pacific Ocean. Smaller adult females migrate to the Gulf of Alaska and California Current ecosystems, where surface wind speeds decline, mixed-layer depths shoal, and coastal production is fueled by upwelling, coastal capes, and eddies, and migrate less commonly to the Transitional Zone Chlorophyll Front, where productivity is relatively high and fronts and eddies may concentrate prey. Surface wind speed and direction influence movement behavior of all age and size classes, though to a greater degree in the smaller pups and adult females than adult males. For naïve, physically and physiologically less-capable pups, the timing and strength of autumn winds during migratory dispersal may play a role in shaping migratory routes and the environmental conditions faced by pups along these routes. In combination with other factors such as pup condition, this may play a role in interannual variations in overwinter survivorship.

Ice-associated Seal Surveys in the Eastern Bering Sea: Gathering Baseline Data and Utilizing a Centralized Geospatial Platform

Erin Richmond, Josh London, Peter Boveng, Paul Conn, Erin Moreland, Michael Cameron

Presenter: Erin Richmond

Email: erin.richmond@noaa.gov

Ice-associated seals are key components of Arctic marine ecosystems and are important subsistence resources for northern coastal Alaska Native communities. The four species of ice-associated seals commonly found throughout the Bering Sea are bearded seals, *Erignathus barbatus*; ribbon seals, *Histriophoca fasciata*; ringed seals, *Pusa hispida*; and spotted seals, *Phoca largha*. These species rely heavily on sea ice as habitat during the spring and summer for rearing pups and molting and are a focus of conservation concern due to expected loss of sea ice habitat. Reliable distribution and abundance estimates for these species are crucial for developing sound plans for management, conservation, and responses to potential environmental impacts.

Biologists at the NOAA Alaska Fisheries Science Center conducted aerial surveys in the eastern Bering Sea during the spring of 2012 and 2013. Surveys were flown using a fixed-wing aircraft with a paired system of digital cameras and thermal imagers mounted in the belly port. Data collection consisted of digital color and thermal imagery, GPS tracklines, and aircraft attitude. In addition to the aerial survey data, existing environmental covariate datasets were obtained to help explain seal haulout behavior. These include daily sea ice concentration and 8-times-daily weather variables such as temperature, wind speed, pressure and precipitation. All survey data and environmental covariate data were imported to a central geospatial PostgreSQL/PostGIS database for data management and scientific analysis. Storing data in a centralized database platform allows users to connect directly to the data and provides accessibility through a variety of software programs including ArcGIS, QGIS and R.

At this time, three main data products have resulted from this effort to gather data on distribution and abundance of ice-associated seals in the eastern Bering Sea: 1) total surveyed trackline length used to calculate the area flown, 2) observed seal sightings and 3) a species distribution model with predicted abundance estimates for each of the four species. The use of a PostgreSQL/PostGIS platform to manage and analyze data was pivotal in getting to this point.

Watching Walrus

Alexander Thornton

Presenter: Alexander Thornton

Email: aethornton@alaska.edu

This project investigates abundance at Pacific walrus haulout sites, comparing recent and historical trends, considering climate change, and anthropogenic disturbances. Listed as a Candidate under the U.S. Endangered Species Act, walruses are an important subsistence species for indigenous peoples both nationally and abroad, but their foraging habitat overlaps key oil/gas development lease areas and walrus are sensitive to even relatively small disturbances.

This poster describes the use of serial images from still cameras to capture and define patterns of walrus abundance and haulout use at five known sites in Bristol Bay (Bering Sea) as well as comparisons between three types of counting methods (still image, human, and mathematical determinations from geospatial analysis). Upon project completion, there will be a better understanding of walrus habitat use with insight focused on areas with shared resources. Final data will be shared with environmental managers so that they may better understand and protect at-risk walrus populations.

WAVE 1

Tuesday, January 26
6:00 pm – 7:15 pm

The Effects of a Climate-Change Induced Reduction in Sea Ice Coverage on Storm Surge Response in Alaska

Joannes Westerink, Brian Joyce, Robert Grumbine, Andre van der Westhuysen, Jesse Feyen

Presenter: Joannes Westerink

Email: jjw@nd.edu

The western coastline of Alaska is highly susceptible to powerful storms that can cause coastal erosion and flooding, significantly impacting the local population and habitats, the environment, and commercial efforts in the region. Storms such as the November 2011 Bering Sea cyclone have ravaged coastal communities with flooding, ice shove, and millions of dollars in damages. In addition, these storms are more common in the non-summer months, when extensive ice coverage is present in the region. During colder months, the surface stresses generated on the water by coastal storms are heavily influenced by the ice coverage. High-density ice coverage reduces the traction of the wind field on the surface of the water. In contrast, sparse drifting sea ice increases the traction the wind possess, leading to greater surge. A reduction in ice coverage during the winter months due to climate change could increase the severity and frequency of this coastal erosion and flooding.

An ADCIRC unstructured grid circulation model has been developed that can accurately model the complex hydrodynamics and topography present along the intricate Alaskan coastline from the Gulf of Alaska to the Beaufort Sea. ADCIRC is a high resolution, finite element, free surface circulation model used extensively by FEMA, the US Army Corps of Engineers and others to model regions such as the Gulf of Mexico, the East coast of the United States, and the Great Lakes. This model is capable of modeling tides as well as storm surge and wind-wave interaction in response to meteorological forcing. ADCIRC also has the ability to include ice coverage, and this feature has been used by the Army Corps of Engineers in their modeling efforts in Alaska as well as the Great Lakes. Incorporating ice coverage quantifies the effect that a reduction of ice coverage can have on coastal flooding by addressing the the joint probability of reduction in ice coverage and coastal storms. In this talk we will present the development of the ADCIRC model and the possible implications of a climate-change induced reduction in sea ice coverage with respect to coastal storms and flooding on the Alaskan coast.

Shelf-basin Exchange in the Bering Canyon in Southeastern Bering Sea: Role of Unimak Pass

Wei Cheng, Carol Ladd, Albert Hermann, Phyllis Stabeno

Presenter: Wei Cheng

Email: wei.cheng@noaa.gov

Shelf-basin exchanges in the southeastern Bering Sea have significant implications for primary production of the region; yet, the mechanisms influencing such exchanges are not well understood. We focus our attention on Bering Canyon, the southern-most canyon transecting the Bering Sea shelf break. In this region, flow from the Pacific to the Bering Sea through Unimak Pass meets and interacts with flow from the Aleutian North Slope Current (ANSC). As a result, the cross-shelf transport may be enhanced in this area. We use time series of currents from four moorings, along with numerical model experiments to test this hypothesis and examine the influences of the various currents.

Results thus far suggest that on seasonal and longer time scales, the onshore flow across the Bering Canyon left rim is influenced by the Unimak pass transport, and to a lesser extent by the transport associated with the ANSC. Both Unimak Pass transport and ANSC transport are highly correlated with the along-shore wind stress south of the Aleutian Island Chain, but the Unimak Pass transport responds faster to the along-shore wind forcing by a month. These results highlight the importance of Unimak Pass in setting up the regional circulation and influencing shelf-basin exchange.

A Biophysical Modeling Approach to Understanding Red King Crab Larval Drift in Bristol Bay, Alaska

Benjamin Daly, Carolina Parada, Albert Hermann, Sarah Hinckley, Timothy Loher, David Armstrong

Presenter: Benjamin Daly

Email: ben.daly@noaa.gov

We present the conceptual design and preliminary results for an ongoing study aimed to better understand the spatial connection between red king crab (*Paralithodes camtschaticus*) larval release and post-larval settlement areas in Bristol Bay, Alaska.

Red king crab larvae spend months in the water column and have specific habitat requirements upon settlement, which implies that the location of larval release relative to oceanographic processes and suitable juvenile habitat is important for determining recruitment success or failure in a given year. Our project couples a biophysical individual-based model (IBM) and a Regional Ocean Modeling System (ROMS) circulation model to evaluate the importance of 1) climate and oceanographic conditions, and 2) female spatial distribution on larval advection trajectories. We refined an existing ROMS model by focusing on the Bristol Bay region, developed a finer scale (2 km) horizontal resolution grid that includes all circulation features and settlement areas relevant to red king crab larvae, and focus on three representative years with contrasting bottom temperature conditions (1999-cold, 2005-warm, 2007-intermediate). ROMS output, in the form of velocity, temperature, and salinity fields, drives the Lagrangian IBM, which tracks virtual larvae in space and time. The IBM incorporates the most extensive biological information available for red king crab, including ovigerous female spatial distribution, fecundity, hatch timing, larval behavior, growth, and settlement habitat. Complementary size-fecundity analyses suggest that the actual number of larvae released in Bristol Bay in 1999, 2005, and 2007 ranged from approximately 2.3×10^{12} to 5.3×10^{12} and were primarily hatched in south-central Bristol Bay. A comprehensive analysis of invertebrate and sediment data suggests that optimal settlement habitats are primarily located inshore of the 50 m isobath. While full model simulations have not yet been conducted to assess advection trajectories, preliminary sensitivity analyses show that ROMS horizontal resolution influences direction and extent of advection, and the number of particles tracked affects the stability of the IBM results. Upcoming model simulations will address effects of model year, female spatial distribution, larval behavior, and hatch timing on large-scale advection.

The Bering Sea Project Archive: a Prototype for Improved Discovery and Access

Don Stott, Matthew Mayernik, Michael Daniels, James Moore, Steven Williams, John Allison

Presenter: Don Stott

Email: stott@ucar.edu

The Bering Sea Project was a research program from 2007 through 2012 that sought to understand the impacts of climate change and dynamic sea ice cover on the eastern Bering Sea ecosystem. More than 100 scientists engaged in field data collection, original research, and ecosystem modeling to link climate, physical oceanography, plankton, fishes, seabirds, marine mammals, humans, traditional knowledge and economic outcomes. Over the six-year period of the program hundreds of multidisciplinary datasets coming from a variety of instrumentation and measurement platforms within thirty-one categories of research were processed and curated by the National Center for Atmospheric Research (NCAR) Earth Observing Laboratory (EOL).

For the investigator proposing a field project, the researcher performing synthesis, or the modeler seeking data for verification, the easy discovery and access to the most relevant data is of prime importance. The heterogeneous products of oceanographic field programs such as the Bering Sea Project challenge the ability of researchers to identify which data sets, people, or tools might be relevant to their research, and to understand how certain data, instruments, or methods were used to produce particular results.

EOL, as a partner in the NSF funded EarthCollab project, is using linked open data to permit the direct interlinking of information and data across platforms and projects. We are leveraging an existing open-source semantic web application, VIVO, to address connectivity gaps across distributed networks of researchers and resources and identify relevant content, independent of location. We will present our approach in connecting ontologies and integrating them within the VIVO system, using the Bering Sea Project datasets as a case study, and will provide insight into how the geosciences can leverage linked data to produce more coherent methods of information and data discovery across large multi-disciplinary projects.

ShoreZone Imaging and Mapping in Alaska

Cindy Hartmann Moore, Steve Lewis, G. Carl Schoch, Mandy Lindeberg

Presenter: Cindy Hartmann Moore

Email: cindy.hartmann@noaa.gov

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

Approximately 114,627 km of ShoreZone imagery exists for the Pacific Northwest coastline including the entire shoreline of Oregon (1,340 km), Washington (4,933 km), British Columbia (37,619 km), and 70,735 km of the Alaskan coastline. The Alaska ShoreZone imaging and mapping project is on-going with ~ 86% of the coast imaged and mapped or with mapping in progress and ~ 14% (11,265 km) of the coastline remaining to be imaged. The Alaska imagery can be viewed online at http://alaskafisheries.noaa.gov/shorezone/.

The Alaska ShoreZone program is built on a foundation of multiple funding and contributing partners, including state and federal governmental agencies, nonprofit organizations, and private industry, as well as resource managers, scientists, and spatial data specialists. The multi-organization program provides a framework to build on and supports a contiguous, integrated coastal resource database that extends from Southeast Alaska through the Gulf of Alaska, the Alaska Peninsula, Bristol Bay, and northwards to Kotzebue Sound, and the Chukchi and Beaufort Seas.

The program goal is to have all of the Alaskan shoreline imaged and mapped using the ShoreZone protocol and to make this data web accessible. The partnership is actively seeking additional partners to help accomplish this goal.

Biogeography of Seabird Assemblages in the Bering Sea: Spatial Assessment of Oceanographic Drivers and Functional Overlap with Fish and Zooplankton

Jarrod Santora, Lisa Eisner, Kathy Kuletz, Carol Ladd, Martin Renner, George Hunt

Presenter: Jarrod Santora

Email: jsantora@ucsc.edu

Integrated ecosystem assessments involving syntheses of the distribution and abundance of lower and upper trophic levels reduce ambiguity about the location of key food web interactions. We assess how broad-scale changes in seabird assemblages relate to ocean physics and their functional relationship to the spatial organization of forage species, including juvenile and larval fish and zooplankton. Our overarching hypothesis is that the along-shelf distribution and abundance of seabirds during summer will reflect underlying hydrography, with an abrupt change in middle shelf domain seabird species composition and abundance at about 60°N, where there is a strong across-domain front. There is evidence that food webs differ north and south of this front, so we hypothesize that seabirds with differing diets will predominate north and south of the front. Using the North Pacific Pelagic Seabird Database, we developed spatial climatologies (1975-2014) of summer (May-September) species abundance and richness (50x50km grid), and quantified a spatially-explicit multivariate index of seabird assemblages. Furthermore, we linked seabird assemblages to results of an oceanographic model (e.g., temperature, current velocity) and to the distribution and abundance of fish catches. Spatial coherence among ocean conditions and overlap among the distribution of fish species and seabird assemblages indicate the following unique seabird biogeographic regions: (a) southeast Bering Sea Inner-Middle shelf domain, (b) outer shelf-slope domain, (c) central-northern Inner-Middle shelf domain, and (d) northern Anadyr Current. Furthermore, we found marked coherence among spatial gradients of abundance of seabird species and forage fish within each biogeographic region. Finally, we highlight the location of trophic hotspots in order to benefit spatial management of the Bering Sea Ecosystem.

Water Mass Properties and Juvenile Chinook Salmon; a Look at Warm and Cold Years in the Northern Bering Sea

Jeanette Gann and Jordan Watson

Presenter: Jeanette Gann

Email: Jeanette.gann@noaa.gov

The oceanography and shelf dynamics of the southern eastern Bering Sea (EBS) have been well-studied, while less attention has been given to the northern EBS, although commercially important fisheries are present in both the south and the north. Sea ice extent and duration, and freshwater inputs from the Yukon River are substantially higher in the north compared to the south, resulting in large variations in oceanography between the northern and southern EBS and between localized areas within the northern EBS. Generalized additive models (GAMs) were fit with environmental and biological covariates (temperature, chlorophyll a, salinity, silicate concentration, Pacific Herring, and Capelin) to look at juvenile Chinook distribution changes between warm and cold years in the northern EBS. Two categories (top 10m 'Surface', and bottom 10m 'Bottom') were investigated for both warm and cold years. Distributions varied between warm and cold years, both in terms of biomass and in terms of their model fits. Both cold year categories (surface and bottom) had higher deviances explained (>50%) and significant associations with a greater number of environmental covariates. Further investigations including the role of water column stability on juvenile Chinook distribution are ongoing.

High-Seas Movement and Behavior of Chinook Salmon, Elucidated with Pop-Up Satellite Tags

Andrew Seitz, Michael Courtney, Mark Evans, Trey Walker, Jim Murphy

Presenter: Andrew Seitz

Email: acseitz@alaska.edu

To examine the oceanic ecology of Chinook salmon, about which little is known, we are conducting a proof-of-concept study in which large, immature Chinook salmon are tagged with pop-up satellite archival transmitting tags in the Bering Sea. While externally attached to the fish, the tags measure and record ambient light (for daily geoposition estimates), depth and temperature data. On a pre-programmed date, the tags release from the fish, float to the surface of the ocean and transmit the recorded data to overhead satellites which are then retrieved by project investigators. Most tagged Chinook salmon have remained in the Bering Sea while occupying depths to 200 m and water temperatures from 4 to 13°C during summer and autumn. Based on temperature records, predation of Chinook salmon by salmon sharks occurs in the Bering Sea. One additional tagged Chinook salmon left the Bering Sea and transited across the Gulf of Alaska while occupying depths to 500 m and water temperatures between 3 and 9°C during winter. These data provide valuable information about regional oceanic ecology of Chinook salmon, which may be used in a variety of ways, such as for improving bioenergetics models, avoiding bycatch, and informing evaluation of high-seas salmon survey data.

Satellite-reporting Accelerometer Tags for Monitoring Survival of Trawler-Deck Released Halibut

Craig Rose, Julie Nielsen, Todd Lindstrom, Tim Loher, Paige Drobny, John Gauvin, Andrew Seitz

Presenter: Craig Rose

Email: fishnextresearch@gmail.com

Bycatch mortality of halibut captured by trawls has been a critical management issue since trawl fisheries have fished Alaskan waters. The intensity of conflicts around that issue has greatly increased recently, due to declines in halibut available to the commercial halibut longline fishery. Demand and efforts to understand and reduce halibut bycatch mortality have increased commensurately.

Under existing handling requirements, trawl-caught halibut cannot be released until they are available for sampling in the vessel's factory. The resulting release delays have the potential to produce high mortality rates. Bering Sea bottom trawlers are developing methods for quickly sorting halibut from catches, while allowing effective accounting of their numbers, size, and survival. Success of this effort depends on accurately measuring how many of the released halibut survive. In a prior study that used large pop-up satellite tags equipped with accelerometers, apparent halibut movements indicated in acceleration data, primarily by changes to tag tilt, were confirmed by changes in depth. We plan to measure 60-day survival of released halibut with pop-up tags, but need small, reliable, and relatively inexpensive tags that will indicate halibut survival by detecting voluntary movements.

Three halibut were tagged with Wildlife Computers MiniPAT9 pop-up satellite tags with depth, accelerometer, light, and temperature sensors and released in a mostly enclosed bay in Southeast Alaska. Scheduled to record data for 24 days and subsequently release, tags were located and recovered, allowing access to full archival data recorded at one second intervals. Analysis of these data found very different behavioral patterns among specimens, but consistent correspondence between activity patterns as indicated by changes in depth and in tag tilt. Halibut movement bouts were well defined and interspersed by long stationary periods. For our primary study, an efficient movement detection algorithm, based on acceleration patterns, is proposed and will be incorporated into Halibut Survivorship PAT tags (Halibut sPAT); simplified tags with the same shape, but equipped only with accelerometer and wet/dry sensors. This will provide a valuable tool for monitoring survival of sedentary species like halibut and provide a modern validation of current survival estimation methods based on viability assessments.

Fishery Interactions with Skate Nursery Areas in the Eastern Bering Sea

Duane Stevenson, Gerald Hoff, James Orr, Ingrid Spies, Chris Rooper

Presenter: Duane Stevenson

Email: duane.stevenson@noaa.gov

Since early 2015, fishery observers in the North Pacific Groundfish and Halibut Observer Program have been receiving training in the identification and sampling of skate egg cases. The goal of this training has been to support an NPRB project examining the unique properties of skate nursery sites in the eastern Bering Sea and the interactions of fisheries with skate egg cases. During the 2015 training year, over 230 observers received training in egg case identification and sampling, and recorded data on nearly 1000 skate egg cases. A total of 9 skate taxa were identified from egg cases, and over half (58%) of the egg cases were identified as Alaska skate (*Bathyraja parmifera*). Observers scored each egg case as either "viable", meaning it contained an intact egg or embryo in some stage of development, or "non-viable", meaning it was either empty or full of mud. Approximately 33% of the egg cases sampled by observers were classified as viable. Program wide, almost 7,000 skate egg cases were encountered by observers. The majority of those egg cases (78.8%) were encountered on longliners targeting Pacific cod in the Bering Sea. Egg case encounters were concentrated on the outer shelf of the eastern Bering Sea, and over half of all egg cases reported were encountered in the area of Bering Canyon. Data collection for this project will continue through 2017, by which time we hope to have a comprehensive overview of fishery interactions with skate nursery areas in the eastern Bering Sea.

Do Pollock Dive in the Response to Survey Bottom Trawls?

Stan Kotwicki, Alex De Robertis, Kresimir Williams

Presenter: Stan Kotwicki

Email: stan.kotwicki@noaa.gov

Walleye pollock (Gadus *chalcogrammus*) are a dominant species with important commercial and ecological roles in the North Pacific. Due to their semi-demersal distribution, separate bottom trawl (BT) surveys and acoustic trawl (AT) surveys are used to estimate their abundance and to determine spatial distribution in the eastern Bering Sea (EBS). Combining BT and AT data can provide more accurate and precise abundance estimates than what can be provided by either survey alone. However to combine data from both surveys it is necessary to know the effective fishing height of the BT. Effective fishing height for the 83–112 otter trawl used in the Eastern Bering Sea BT surveys has been estimated to be on average 16 m above bottom using modelling techniques, which combined BT and AT data. This estimate suggests that pollock dive into the trawl opening because the headrope height of the BT is only 3m. However this diving behavior has not been confirmed with observations. Direct observation of pollock diving behavior will validate the inferences from the model results and will allow application of effective fishing height estimates to derive combined BT and AT abundance estimates for pollock stock assessment and other studies. The goal of this presentation is to explain sampling of pollock by the BT and AT techniques, present the modelling results, and show progress to date on a recently funded NPRB project to conduct observations of pollock behavior in the front on the survey BT. Diving behavior will be assessed by comparing the vertical distribution of pollock as encountered by the trawl vessel and when they encounter the trawl using echosounders. A small boat containing an echosounder will be towed by BT survey vessel over the trawl. The position of the boat relative to the trawl will be controlled from the survey vessel, which will allow for observations of pollock vertical distribution in any point between the fishing vessel and the trawl opening.

Exploration of Potential Early Life Mortality in Chinook Salmon Eggs due to Thiamine Deficiency

Corey Fugate, Sean Larson, Katie Howard

Presenter: Corey Fugate

Email: corey.fugate@noaa.gov

Since 2007 the Yukon River Chinook salmon returns have declined by approximately half the historical size. The driving force behind this decline is still poorly understood; however, one possible explanation may involve thiamine deficiency. Thiamine is required for numerous body functions, including muscle and nervous system function, digestion, and the metabolism of carbohydrates, fats, and proteins. Thiamine deficiency has been demonstrated to be responsible for numerous salmonid populations and is often a result of shifting feeding habits. In 2013, eggs were collected from 30 female Chinook salmon returning to the upper reaches of the Yukon River. Total egg thiamine concentrations were measured by fluorescence spectroscopy coupled with high performance liquid chromatography. The mean total egg thiamine was replete at most collection sites. However, the data were highly variable and 33% of the females analyzed had total egg thiamine concentrations associated with adverse growth, vision, predator avoidance and immune function. Given the high variability in thiamine concentrations, the sample size and sample area was increased for the 2014 and 2015 returns in order to determine if interannual levels of thiamine deficiency occur on the Yukon River.

Decreased pH Changes Juvenile Blue King Crab Morphology and Decreases Growth and Survival.

William Long, Scot Van Sant, Katherine Swiney, Robert Foy

Presenter: William Long

Email: Chris.long@noaa.gov

Blue king crabs, *Paralithodes platypus*, have been an important fishery species in the Bering Sea. Large fluctuations in biomass of this species in the Pribilof Islands and the St Matthew Island regions suggests that recruitment processes are complex and are sensitive to environmental variability. In addition, there is a potential for blue king crab to be affected by decreases in ocean pH as a result of increasing atmospheric pCO_2 levels, a process known as ocean acidification. In this study, juvenile blue king crabs were exposed to three pH levels in a long-term experiment to determine the effects of ocean acidification. Thirty, first crab stage juveniles were reared at ambient pH, pH 7.8, and pH 7.5 for one year. Crabs were checked daily for molts and mortalities and the morphometry and wet weight were determined after every molt. Reduced pH, particularly at the pH 7.5 level, was associated with a change is morphology, reduced growth, and increased mortality. Interestingly, the effect of pH on the mortality rate was highest at the beginning of the experiment, but declined so that at the end it was similar among the three treatments. The juveniles of other Alaskan crab species, the red king crab, *Paralithodes camtschaticus*, the Tanner crab, *Chionoecetes bairdi*, both had higher mortality rates under the same conditions indicating that blue king crab may be more resistant to ocean acidification. However, given the current low population levels in blue king crab, slower growth rates and increased juvenile mortality rates at low pH will likely lead to lower recruitment success and population level effects as ocean acidification increases in the Bering Sea.

Application of an Age-Length Structured Population Dynamics Model to Data for Eastern Bering Sea Tanner Crab (*Chionoecetes bairdi*) and Pacific Cod (*Gadus macrocephalus*)

Caitlin Allen Akselrud, Andrè Punt

Presenter: Caitlin Allen Akselrud

Email: cia2@uw.edu

Fishery stock assessments are frequently based on age-structured population dynamics for fish and length-structured dynamics for invertebrates. We have developed and implemented a model to account for both age and length dynamics for an individual fishery. An age-length assessment model is unique in its ability to capture the dynamics of fishing mortality and natural mortality on fish populations, which are functions of both length and age. By accounting for both age and length, the age-length model should reduce estimation bias present in models that only account for age (or length) dynamics, and assist managers in achieving statutory goals for fishery management.

Simulation studies have showed that the age-length models can provide essentially unbiased estimates of biomass trajectories and have low sensitivity to the precision of the data. Here we evaluate these models using the actual data for the Eastern Bering Sea Tanner crab (*Chionoecetes bairdi*) and Pacific cod (*Gadus macrocephalus*) fisheries. These data include catches, fishing effort, and survey index, as well as length-composition and conditional age-at-length. Survey and fishery data (including several fleets) are available for each stock. We compare the results of our new age-length model against current stock assessment model results for each species. Uncertainty is characterized using Bayesian methods. Posterior distributions for parameters are sampled using a Markov Chain Monte Carlo approach. Fit to the data is evaluated with a range of diagnostics, including posterior predictive intervals for the observed data.

Ontogenetic Shifts in Energetic Content and Diet of Juvenile Yukon River Chinook Salmon

Wesley Strasburger, Emily Fergusson, Jim Murphy

Presenter: Wesley Strasburger

Email: wes.strasburger@noaa.gov

Over the last decade the production of Yukon River Chinook Salmon has declined to levels eliciting the closure of commercial and reduction of subsistence fisheries, respectively. The decline in production is not yet understood. Recently, low numbers of juvenile-per-spawner, and subsequently, returns-per-spawner, seem to confirm the hypothesis of low production due to high early life history mortality. Whether this mortality is more pronounced in the freshwater or marine phase of Chinook salmon early life history is an important piece of information that is lacking. The failure of multiple stocks throughout western Alaska seems to suggest a large scale, and more likely marine explanation. A better understanding of the transition between freshwater and marine feeding and energetic strategy, and thus early marine survival, will increase our ability to forecast and understand adult returns. Estuarine, and marine phase juveniles were collected during two different survey efforts from August-September during both 2014 and 2015. Samples were preserved and returned to Auke Bay Labs (NOAA) in Juneau, Alaska for dietary and energetic processing. Both dietary composition and energetic content shifted over time, with the dietary composition generally increasing in oceanic influence over time and with increased body length. Additionally, prey items ingested shifted with increasing time from surface oriented prey field to pelagic prey fields. Energetic content continued to increase over time and fish body length, especially with the introduction of highly energetic marine prey content. Additionally, a shift in long standing dietary patterns of September marine juveniles was observed for the 2014 and 2015 survey years. Diets shifted from a predominantly piscivorous nature in previous years to a diet dominated by juvenile crab.

Age-0 Pollock Prey Type and Quality as an Indicator of Recruitment Success in the Southeastern Bering Sea

Alex Andrews, Mary Auburn-Cook

Presenter: Alex Andrews

Email: alex.andrews@noaa.gov

Climate change in the southeastern Bering Sea has affected Walleye Pollock (*Gadus chalcogrammus*) recruitment success through bottom up changes to the prey base. Reductions in the quality and quantity of age-0 pollock prey have been correlated to lower energetic content of age-0 pollock and thus poor overwinter survival. Based on these findings, we propose to use onboard diets from the BASIS survey to provide a rapid assessment of prey quality as a predictive indicator of recruitment success. Composition of prey will be summarized for the southeastern Bering Sea by taxonomic group. We will calculate a weighted average of the energetic content of pollock diets using energetic density values from the literature. The weighted averages of dietary energetic content will be compared with age-1 recruits per spawner for the following summer. Our goal is to provide fisheries managers and stock assessment scientists with an early indicator to predict recruitment success.

Interpretation of Essential Fish Habitat Regulations in the United States

Aileen Nimick, Brad Harris

Presenter: Aileen Nimick

Email: animick@alaskapacific.edu

In the United States the Magnuson Stevens Fisheries Conservation and Management Act mandates that federal commercial fisheries managers designate and protect Essential Fish Habitat (EFH). The statute requires that adverse impacts to EFH be minimized to the "extent practicable". Federal regulations define "adverse impacts" as those that reduce the quality and/ or quantity of EFH in a manner that is "more than minimal and not temporary". Neither the statute nor the Final Rule establish clear guidelines for what constitutes "minimal" or "temporary" and therefore regional fisheries councils are afforded broad scope for interpretation. This poster will highlight the similarities and differences between the regional councils' interpretations of the EFH regulations and consider the implications for Congress's intended protections. It will also provide examples of work our lab has been involved with to quantify benthic impacts of fishing.

Chemical Feeding Ecology of Hg in Bering Sea and Aleutian Island Groundfish

Andrew Cyr, Lorrie Rea, Judith Castellini, Todd Loomis, Todd O'Hara

Presenter: Andrew Cyr

Email: acyr1@alaska.edu

Numerous fish and invertebrate species inhabiting the Bering Sea and Aleutian Islands have significant commercial value as seafood, but also constitute a significant portion of many marine mammal and other higher trophic level organism diets. Mercury (Hg) concentrations are a significant concern in Steller sea lions (*Eumetopias jubatus*) and Pacific halibut (*Hippoglossus stenolepis*) from certain areas of the Bering Sea and the Aleutian Islands. To better understand the chemical feeding ecology of Hg in groundfish, we assessed muscle Hg concentrations (n = 431) relative to fish fork length and $\delta^{15}N$ values in ten fish species. Mercury concentrations across individual fish ranged from 0.0078 to 1.5783 mg/kg wet weight (200-fold) and $\delta^{15}N$ ratios ranged from 3.97 ‰ to 14.95 ‰ (3.8-fold). Yellow Irish lord (*Hemilepidotus jordani*) had a 16-fold higher mean Hg concentration (0.8195 ± 0.382 mg/kg ww) than Magister armhook squid (*Berryteuthis magister*) with the lowest (0.0506 ± 0.016 mg/kg ww). Average $\delta^{15}N$values were highest in Yellow Irish lord at 12.73 ‰, and lowest in Atka mackerel (*Pleurogrammus monopterygius*) at 9.36 ‰. Mercury concentrations correlated positively with fish fork length in eight of ten species and $\delta^{15}N$ values in five of ten species. Regression analysis of Hg concentrations and $\delta^{15}N$ values was significantly influenced by species as a covariate. We conclude that Hg concentration is not always dependent on fish length or the relative enrichment of $\delta^{15}N$ in muscle tissues. In order to best understand and quantify mercury concentrations within a taxonomic group and within a food web, multiple metrics must be incorporated, including feeding ecology of the species, fish age and/or length, and relative $\delta^{15}N$ enrichment.

A Very Detailed Examination of Bering Sea Pollock Catcher Vessel Trips

Jordan Watson, Alan Haynie

Presenter: Jordan Watson

Email: jordan.watson@noaa.gov

In the last two decades, the Bering Sea pollock fleet has seen many changes, including the creation of catch shares, spatial closures for Steller sea lion conservation and salmon bycatch protection, and the development of a hard cap and incentive measures to reduce Chinook bycatch. Meanwhile, numerous studies have either examined or predicted large-scale changes in the Alaska marine ecosystems as a result of regime shifts and longer-term changes in climate. Using observer, fish ticket, and vessel monitoring system data, we reconstructed the paths of nearly 50,000 trips made by catcher vessels that fished for pollock in the Bering Sea from 2003 - 2013. We divided fishing trips into those targeting pollock in the Bering Sea or those targeting other species or other regions of the North Pacific. By then characterizing trip durations and distances, we were able to quantify catch per unit effort (CPUE) for observed and unobserved fishing trips, as well as vessels' time and distance traveled from port. This fisher-centric effort was compared with the stock-centric version of CPUE, which bases effort on haul durations instead of trip durations, to better understand how these factors are related over time. We were also able to examine the impact of warm and cold years on vessel behavior, and how targeting behaviors varied with changing economic conditions, bycatch, and total allowable catch (TAC).

Four New Species of Foliose Bangiales (Rhodophyta) from the Aleutian Islands and Vicinity

Sandra Lindstrom, Mandy Lindeberg, Daniel Guthrie

Presenter: Sandra Lindstrom

Email: Sandra.Lindstrom@botany.ubc.ca

Foliose Bangiales are one of the world`s most valuable marine crops, with annual sales in the $2 billion range, and a number of species are harvested by indigenous peoples around the world as well. Although none of the species occurring in Western Alaska are harvested, that potential still exists. The only study that has focused on foliose Bangiales in this region is Wynne`s 1972 paper on "The genus *Porphyra* at Amchitka Island, Aleutians." His study was done at a time when morphology was still the main method for seaweed identification. Today, DNA sequencing is essential for identification of species such as foliose Bangiales, which have few morphological characters to distinguish them. We have sequenced the *rbc*L gene in more than 100 collections of foliose Bangiales made in the Aleutian Islands and the western Alaska Peninsula during the past 25 years. This work allows us to recognize four previously undescribed species, two in the genus *Boreophyllum* and two in *Pyropia* (the only species of *Porphyra* currently known to occur in the northeast Pacific are probably introductions, *P. mumfordii* and *P. rediviva*). One of the species of *Boreophyllum* appears to be endemic to the Aleutian Islands; the other is known to occur from the Yakutat area to the tip of the Alaska Peninsula. The two previously undescribed species of *Pyropia* are more broadly distributed. One species, which was previously identified under the name *Pyropia pseudolinearis*, occurs from northern Southeast Alaska through the Aleutian Islands. The other species, which is sister to *Pyropia abbottiae*, occurs from southern Vancouver Island to Attu Island. Collections throughout the Aleutian Islands allow us to document the distribution of another dozen species of foliose Bangiales in this region, including *Boreophyllum aestivalis*, *Fuscifolium tasa*, *Pyropia fallax*, *Py. fucicola*, *Py. gardneri*, *Py. kurogii*, *Py. nereocystis*, *Py. pseudolanceolata*, *Py. torta*, *Wildemania amplissima*, *W. norrisii*, and *W. variegata*.

Where Did All the *Chrysaora melanaster* Go?

Kristin Cieciel

Presenter: Kristin Cieciel

Email: kristin.cieciel@noaa.gov

Chrysaora melanaster has comprised a substantial portion of the BASIS surface trawl data in the North and South eastern Bering Sea since 2003. But it was not until 2004 that all macro-jellyfish caught by trawl were identified to species, measured for bell diameter, and weighed in groups. In 2006, individual weights of the first 50 of each species were added to the methods in the hopes of determining a way to measure jellyfish condition. The jellyfish typically encountered in the trawl are *C. melanaster*, *Cyanea capillata, Aequorea* sp., *Staurophora mertensi*, *Phacellophora camtschatica*,and *Aurelia spp*. From 2009-2014 the southeastern data shows continuous increases of *C. melanaster* and decreases of all other macro-jellyfish species typically encountered in the catch, culminating to a record catch year in 2014 for the south. The same trend seemed to occur in the north but the species assemblage was slightly less pronounced in *C. melanaster* dominance. In 2015 a gear change was instituted in the south (<60°N) portion of our survey ending our time series with surface trawl gear and changing over to oblique tows with a smaller net. The north survey continued to fish the same surface gear in 2015 and recorded dramatic decreases in the catch of *C. melanaster* and increases in the overall species assemblage for macro-jellyfish. Catch data will be compared to physical ocean variables and zooplankton data to look at longterm trends and possible relationships for fluctuations in *C. melanaster* abundance and biomass.

Mercury Concentrations in Freshwater Forage Fish from the Aleutian Archipelago: Spatial Patterns and the Influence of Land Use and Seabird Biotransport

Leah Kenney, Frank von Hippel, Robb Kaler, Collin Eagles-Smith, Josh Ackerman

Presenter: Leah Kenney

Email: leah_kenney@fws.gov

The Aleutian Archipelago (Aleutians) is an isolated arc of >300 volcanic islands stretching 1,600 km and separates the North Pacific Ocean and Bering Sea. Despite the remoteness of the Aleutians, elevated levels of contaminants, including mercury, have been documented in marine organisms throughout the archipelago. The Aleutians are a critical region for avian conservation, supporting more than ten million seabirds, as well as sea ducks and waterfowl that rely on freshwater ecosystems for foraging and breeding habitat. Elevated levels of mercury in forage fish pose serious health consequences for fish-eating wildlife. While generally considered pristine, some islands in the Aleutians have been heavily impacted by military activities since World War II and potentially exposed to long-range contaminant transport via atmospheric deposition, prevailing ocean currents, and biotransport. We evaluated mercury concentrations of 1,121 resident-freshwater fish samples of two species, the threespine stickleback (*Gasterosteus aculeatus*) and Dolly Varden (*Salvelinus malma*). Samples were obtained across a 3,000 km longitudinal gradient of 11 islands spanning from the western Aleutians to the Gulf of Alaska. Mercury concentrations for stickleback and Dolly Varden differed significantly among islands. There were no apparent longitudinal trends in mercury concentrations, nor were there differences in fish mercury concentrations between islands with and without military installations. Within islands, fish from lakes used by marine birds had higher mercury levels than those in lakes that did not support marine birds. Fish mercury concentrations were higher in lakes that were on islands compared to mainland sites. At all islands, mean fish mercury levels were high enough to be of concern to the health of piscivorous wildlife. These results provide the first mercury levels in resident-freshwater fishes across the Aleutians, and provide important baseline information for which to further elucidate sources and pathways of mercury exposure between marine and freshwater environments.

Tufted Puffins: A Success Story across a Vast Area, Despite High Variability in Diet and Marine Habitat

Sarah Schoen, John Piatt, Mayumi Arimitsu, Erica Madison, Gary Drew, Martin Renner, Brielle Heflin, David Douglas

Presenter: Sarah Schoen

Email: sschoen@usgs.gov

An adequate food supply is fundamental to the breeding success and healthy population trends of seabirds. Are colonial-nesting seabirds able to compensate for variability in the composition and availability of prey near their colonies? This is a question central to understanding the mechanisms underlying population trends and demographics of seabirds that breed across large ranges and among different marine environments. Using Tufted Puffins as samplers of forage fish communities, we studied marine food webs during August of 2012-2014 at breeding colonies ranging over a 2,400 km gradient from Kodiak Island to the western Aleutian Islands. We quantified habitat characteristics likely to influence forage (slope of the sea floor, percent of area shallower than 200 m, distance to shelf edge, tide range, and chlorophyll-*a*), oceanographic conditions (temperature and salinity), forage nekton biomass (inferred from hydroacoustic biomass), and seabird composition and density at sea in the marine environment surrounding each puffin colony. At the colonies, we collected puffin chick-meals to characterize forage communities, and measured chicks to obtain an index of their body condition. Cluster analysis of oceanographic conditions identified three distinct ecoregions within our study area including: the 1) western Aleutians, 2) eastern Aleutians, and, 3) Alaska Peninsula islands. Correspondingly, environmental conditions around colonies (including habitat characteristics and oceanographic conditions) were significantly different among ecoregions. The community composition, species richness, and biomass of forage fish differed markedly among ecoregions, and the at-sea density of Tufted Puffins varied among ecoregions; however, indices of chick condition did not. Across the entire study area, environmental conditions strongly predicted the acoustic biomass of forage near colonies. Further, both forage biomass and the combination of forage biomass and select environmental variables (chlorophyll-*a* and oceanographic conditions) predicted the density of Tufted Puffins at sea. Our results provide evidence that Tufted Puffins were able to produce healthy chicks of similar condition across a wide range of environmental conditions, despite differences in prey abundance, richness, and composition. The ability of Tufted Puffins to successfully exploit widely differing prey communities and environmental conditions may be the key to their overall success and wide distribution across the North Pacific Ocean.

Slaty-Backed Gull as a Commensal on a Sympatric Rookery of Steller Sea Lions and Northern Fur Seals (Dolgaya Rock, Kuril Islands)

Oksana Savenko, Maria Ghazali, Vladimir Burkanov

Presenter: Oksana Savenko

Email: o.v.savenko@gmail.com

Rookeries of eared seals (Otariidae) are abundant sources of nutrition for different types of organisms. Dolgaya Rock (DR) is one of only a few sympatric rookeries of Steller sea lions (SSL; *Eumetopias jubatus*) and northern fur seals (NFS; *Callorhinus ursinus*). Slaty-backed gulls (*Larus schistisagus*) annually form a breeding colony of more than a hundred nests on the top of the DR rookery. The study was conducted in May-July 2010 through daily visual observations; seals were counted visually, adult gulls – from 1600 panoramic pictures. The maximum number of SSL was 906 adults (23 June) and 450 pups (5 July), while the maximum of NFS (9830 adults and more than 6 thousand pups) occurred a month later on 20 July. Gulls and their nestlings regularly ate afterbirths, dead bodies and other waste products of the rookery. The relative number of adult gulls feeding on both the NFS and SSL sites of the rookery increased from May to July ($r = 0.73$, $p<0.001$), from about 1% to 40% of the overall number of counted gulls. Number of feeding gulls associated with SSL sites increased in the last 20 days of June – a period of intense SSL pupping, and then decreased (this relationship was well described with quadratic regression, $p<0.001$, $R^2=0.35$). On the NFS sites, feeding behavior of gulls first appeared in late June and then regularly was recorded in the first weeks of July which coincide with NSF birthing period but we do not have daily NFS pups count data for analysis. The offset in the timing of SSL and NFS breeding allows nesting gulls to use important nutrition resources of the rookery during whole rookery-wide breeding period.

Picking at the Surface: Red-Legged Kittiwake Foraging Behavior in a Year of Poor Laying Success

Rachael Orben, Abram Fleishman, Rosana Paredes, Marc Romano, Scott Shaffer, Alexander Kitaysky

Presenter: Rachael Orben

Email: raorben@gmail.com

For seabirds to function as indicators of ecosystem health it is critical to understand how conditions throughout the annual cycle might mediate life history and demographic responses. Individuals spend their time prior to breeding improving/maintaining body condition, defending nests, and pair bonding. Thus, this period is important in determining if an individual/pair will initiate a breeding attempt. For the Bering Sea endemic seabird, the red-legged kittiwake (*Rissa brevirostris*), the majority of nests fail during either pre-lay or incubation, rather than during chick rearing. Here we present the first individual foraging distributions for red-legged kittiwakes during pre-lay and incubation. In May and June of 2015, we used GPS dataloggers to track red-legged kittiwakes prior to laying (n=10, 100% recovery rate) and during incubation (n=36, 92% recovery rate) from their largest colony located on St. George Island in the south-eastern Bering Sea. Birds largely foraged in the deep waters of the Bering Sea basin and travelled up to 562 km from the colony. Pre-lay foraging trips were predominately westward, whereas incubation trips were both to the west and south. Of the birds tracked prior to egg lay, 30% laid eggs, compared to the colony wide percentage of 48%. Of the breeding birds tracked during incubation, 21% hatched chicks and all these chicks fledged. Colony-wide, 9% of birds that laid eggs hatched chicks, while productivity was only 1%. Our current results provide a baseline for foraging behavior during a year of poor laying and hatching success. The continuation of this study will help to inform the use of reproductive parameters of red-legged kittiwakes as ecosystem indicators of the Bering Sea basin.

The "Warm Blob" and a Cold Sea: Large-Scale Trophic Perturbations in the Aleutian Islands

Douglas Causey, Veronica Padula, McKenna Hanson, Marin Lee

Presenter: Douglas Causey

Email: dcausey@uaa.alaska.edu

The Arctic regions are experiencing rapid change in marine and terrestrial environments from many sources, primarily caused by climate change and anthropogenic impacts of increased development and pollution. A diverse avian community inhabits these regions during summer, comprising terrestrial and marine species of several different upper trophic levels. Several endemic species, such as Red-faced Cormorants (*Phalacrocorax urile*) are currently undergoing dramatic population declines, likely related to climate-related change in food availability and trophic structure of the local marine environment.

This project is focused on the coastal dynamics related to climate change of marine bird communities. We use several data sources and analysis techniques, including diet data, stable isotopes, and Bayesian inference, and encompassing current, historical, and prehistorical time periods. In this study, we are analyzing the constituent stable isotopes (eg. H, C, N, O, S) of blood and feather samples collected from 16 avian species collected in the far Western Aleutian Islands (eg., Near, Rat, and Delarof Islands) since 2000, as well as from archival modern specimens collected as early as 1820.

Our preliminary results indicate that the community-wide spatial and temporal dynamics of marine bird ecosystems are far greater in the last decade (2009 – 2015) than has been evident over recent decades. We also find that the magnitude of change is lesser here in the low Arctic (*e.g.*, western Aleutian Islands 53°N) compared to High Arctic coastal marine ecosystems (*e.g.*, 78°N). In particular, we show that the ecological patterns observed within such widespread arctic species as puffins (*Fratercula* spp.), Northern Fulmars (*Fulmarus glacialis*), and Black-legged Kittiwake (*Rissa tridactyla*) indicate diets are strongly perturbed on small geographic and temporal scales of 10^1 km and decades. Moreover, we find that the variance in environmental and ecological parameters is increasing rapidly over time. We hypothesize that these fine-scale changes are related to mid-scale oceanographic and trophic-level changes (eg., the "Warm Blob"), in addition to larger-scale perturbations possibly related to a cascade of climate-related factors.

A Survey of Potential Prey Items for Waterfowl Broods across Four Sites on the Yukon-Kuskokwim Delta, Alaska

Elizabeth Ruffman

Presenter: Elizabeth Ruffman

Email: Elizabethr@alaskasealife.org

The Yukon-Kuskokwim Delta is a globally important area for wildlife, and supports a high biodiversity and abundance of migrating and nesting marine birds and waterfowl. Changes in the environment due to climate change affect wetland ecology in this region. The purpose of this project is to identify potential diet items for ground nesting waterfowl across coastal areas in the central Yukon-Kuskokwim Delta, and support planning for potential Steller's eider (*Polysticta stelleri*) reintroduction efforts. In 2014, four wetland sites were selected and sampled including Kigigak Island and three sites along the Kashunuk river system, representing a gradient of locations from close to shore to 13 miles inland. Ponds were randomly selected within a 1km radius of each of four established sites, with additional criteria of >500m from same community type and >100m from border of an adjacent community type. Two benthic samples (125ml) were collected from each of the 67 ponds using a 0.5L Van Veen grab. Samples were cleaned, stained with Rose Bengal to identify seeds and invertebrates, separated, identified to family or species when possible, and dried and weighed to obtain dry weight. Sixty-seven pond samples were processed and from those, 33 total potential diet items (22 invertebrates and 11 seeds) were found. Mean biomass (g/ml) and abundance were summarized for each item across the four sites. Overall, Kigigak Island had the greatest mean biomass (g/ml) of invertebrates while Hock Slough had the greatest mean biomass (g/ml) of seeds. Across all pond samples, invertebrates with highest biomass (g/ml) included: Chironomidae, Ostracoda, Copepoda, Nematoda, and Planorbidae. The seeds with highest mean biomass (g/ml) in ponds were *Carex* species, *Hippuris* species, *Zannichellia palustris*, and two unknown seed species.

Using Satellite Imagery to Count Nesting Short-tailed Albatross in the Senkaku Islands: Implications for Alaska's Fisheries

Jane Dolliver, Robert Suryan, Christopher Noyles, Ellen Lance, Catherine Yeargan

Presenter: Jane Dolliver

Email: dollivej@oregonstate.edu

Incidental take of the endangered short-tailed albatross (*Phoebastria albatrus*) is strictly regulated for Alaska fisheries. An accurate count of the breeding population, therefore, is critical for assessing whether the species meets endangered species recovery criteria. Approximately 20% of the population nests on the Senkaku Islands, however, because of territorial disputes between Japan and China, a nesting population count has not been conducted on the Islands since 2002. We are initiating a study to test the efficacy of satellite-based counts of nesting albatross using DigitalGlobe's WorldView-2 and WorldView-3 Satellites (0.5-0.3m monochromatic resolution) and ENVI image processing software. We will compare satellite-based counts with ground counts of three species of albatrosses (short-tailed, Phoebastria albatrus, black-footed, *P*. *nigripes*, and Laysan, *P*. *immutabilis*) at multiple colonies in Hawaii and Japan to test species identification accuracy and determine the correction factor(s) needed to ground truth satellite counts of unknown populations on the Senkaku Islands. Preliminary assessments are promising for separating nesting short-tailed albatross from other ground-nesting species. These methods could be broadly applied to many land-based populations in remote and/or inaccessible areas and at more frequent intervals, especially where human presence impacts ground-based estimates or impacts other species.

The Impacts of Plastic on Aleutian Island Seabirds: Detection of Phthalates in Tissues

Veronica Padula, Douglas Causey, Marin Lee

Presenter: Veronica Padula

Email: vmpadula@alaska.edu

Plastic pollution in the ocean was first reported in scientific literature in the early 1970s. Today, plastic fragments are found in all terrestrial, freshwater, and marine ecosystems, extending from the Arctic to Antarctica. Plastic ingestion is prevalent among seabirds, and has been implicated in large-scale population declines. Seabirds are more threatened than other comparable groups of birds and their status has deteriorated faster over recent decades. In Alaska, seabird populations in the far western Aleutian Islands have been declining for the past few decades, and the underlying mechanisms of these declines are unknown. Seabirds mistake plastic for prey, or as food for chicks. Ingestion can result in ulcerations, starvation, or death. Additionally, plastic debris degrades into microplastics in marine environments, which are carried by ocean currents to the Bering Sea. When ingested, microplastics can pass through a bird's stomach and intestine, where chemicals leach off and get incorporated into tissues. One key group of chemicals causing concern is phthalates, which impart flexibility, pliability, and elasticity to plastics. Phthalates are endocrine disruptors, interfering with homeostatic maintenance. Seabirds are model organisms for studying phthalates, as they are at the top of the food web in the marine ecosystem. Phthalate exposure may be one of the underlying mechanisms for seabird population decline. More research is required to understand long-term consequences of phthalate exposure, and the act of quantifying phthalate levels is the first step. We are currently taking those first steps with seabirds in the Bering Sea. Our preliminary phthalate analyses from seabird muscle tissue show detectable concentrations of six phthalate congeners in muscle tissues. Additionally, phthalates were detected within 11 embryos, indicating these compounds are metabolically active and labile within the adult bird, raising the question of whether or not embryonic exposure to phthalates impacts chick development. This project will continue to provide new information in the ecotoxicological field by building a foundation of knowledge of phthalate exposure in Bering Sea seabirds.

Radiation Monitoring on Prince William Sound Beaches; Year III

Jedediah Dean

Presenter: Jedediah Dean

Email: quantum.torpedo5@gmail.com

Is it radioactive? That's what everyone asks when I tell them that I collect items from Prince William Sound (PWS) beaches with my family when we go boating. I am concerned with what is, and what will be washed up on the beaches of Alaska. I've been concerned ever since the earthquake and tsunami in March 2011. When it occurred, it damaged the Fukushima-Daiichi nuclear reactor in Japan. It has been leaking radioactive material ever since the accident. It has been spewing radioactive water into the Pacific Ocean and contaminating the environment. I believe that when the reactor was damaged, that it contaminated items from the tsunami, and they are now washing onto our coasts. I've been testing beaches across PWS for gamma radiation, a radiation that could only come from a few items, and the reactor in Japan is a suspect. The purpose of my experiment is to test if items are washing up on our beaches are radioactive, such as: natural items (trees, logs, seaweed etc.), flotsam (buoys, Styrofoam, etc.), and marine mammals, have elevated radiation levels on Alaskan beaches.

The procedures for this experiment are as follows:

- Obtain testing equipment
- Arrive at site(s)
- Test area- follow experimental procedure
- Repeat testing procedures at every site
- Record Data

During this season of testing, I found increasing levels of radiation on the beaches. Specifically in two locations radiation levels were measured approximately ten times higher than the previous years. That was when I started to notice a trend; the closer I got to the Gulf of Alaska, the higher the readings were. I believe that this is from being more exposed to the open ocean; so more items will wash up from foreign shores. I tested for one type of radiation; gamma radiation. This year was the third year of testing in a four-year study in PWS.

High-Resolution Model Integrations for the Gulf of Alaska with Realistic Freshwater Inputs from Land

Kate Hedstrom, Seth Danielson, Enrique Curchitser, David Hill, Jordan Beamer, Jonathan Whitefield

Presenter: Kate Hedstrom

Email: kshedstrom@alaska.edu

We describe advances in Gulf of Alaska ocean circulation modeling using the Regional Ocean Modeling System (ROMS) to integrate a grid over 1999-2008 with moderately high horizontal resolution (~1.5 km). The domain extends over 1000 km from east of Icy Bay to west of Shelikof Strait, including Cook Inlet and Prince William Sound, and all of the encompassed shelf and slope regions. The model includes tidal forcing and a wetting-drying algorithm to better capture the behavior of currents and sea level amplitudes and phases in Cook Inlet and other coastal regions that contain extensive intertidal zones. Fresh water forcing is prescribed as a spatially and temporally varying line source imposed as a lateral inflow along the coastal wall wherever terrestrial discharge occurs. The runoff forcing is provided by output from a precipitation, snow/ice melt, and streamflow-routing hydrological model that provides a high-resolution spatially explicit (~1 km grid) and observationally-tuned daily-mean coastal discharge time series [Beamer et al., 2015]. This approach for handling coastal fresh water inputs allows us force the coastal zone with realistic volume, heat and fresh water fluxes. We compare model results to observational data collected by current meter moorings, tide gauge stations, and shipboard hydrographic surveys. The model results allow us to re-assess the pathways, transport, and fate of glacial melt and other terrestrial runoff once within the Gulf of Alaska marine system.

Effects of Glacial and Oceanic Advection on Spatial Patterns of Freshwater Contents and Temperatures in the Late Spring and Summer in Prince William Sound, Alaska: Part 1 1994 To 1997

Shelton Gay III, Stephen DiMarco

Presenter: Shelton Gay III

Email: smg3tx@gmail.com

Using spatial principal component (PC) analysis, the variation in freshwater contents and temperatures in the upper 100*m* is quantified for small fjords and primary basins within Prince William Sound, Alaska. Two EOF modes explain over 90% of the variance in the freshwater content anomalies (*FWCA*) giving the total magnitude and vertical structure of the *FWCAs* respectively. Large, positive PC amplitudes (PCAs) of modes 1 and 2 indicate stratification from surface freshening, whereas positive mode 1 PCAs in conjunction with negative mode 2 amplitudes infer high subsurface freshening due either to vertical mixing or advection. In contrast, basins with negative mode 1 amplitudes are typically salty to slightly brackish, but the mode 2 PCAs determine if *FWC* is concentrated near the surface or mixed deeper in the water column. The vertical structure of the temperature anomalies (*TA*) is more complicated, and at least three EOF modes are required to explain 90% of the variance. The reasons for this include differences in solar heating (i.e. local climates), modulated by cold alpine runoff and advection of cold, brackish surface and subsurface glacial water. Fjords and major basins influenced by the latter exhibit large, positive mode 1 amplitudes of *FWCA* and negative mode 1 and 2 PCAs of *TA* and *FWCA* respectively. In certain fjords, however, advection of glacial water into the outer basins enhances the total *FWC*, whereas other fjords exhibit atypically low *FWC* due to unusual topographic features of the watersheds. This combination of factors leads to generally poor correlations between average *FWC* and watershed to fjord surface area ratios or hydrology. Gradients in FWC between small fjords and major basins are typically weak, and thus the main driver of baroclinic flow in the northern and western sound is cold, brackish surface and subsurface water propagating from large tidewater glacial fjords. The glacial water has a marked affect on the dynamic topography, which shows southerly baroclinic-geostrophic flows annually within western PWS. At Montague Strait and Hinchinbrook Entrance, however, inflows may occur from either fresh or salty conditions; low water density of the latter being shown by large, positive *TA* PCAs.

Gulf of Alaska - Climate and Oceanography

Nutrient Dynamics in the Alaska Coastal Current

Katherine Trahanovsky, Terry Whitledge

Presenter: Katherine Trahanovsky

Email: kat.1@alaska.edu

The Alaska Coastal Current (ACC) is a narrow, shallow, fast-moving current that hugs the Gulf of Alaska coastline and creates a discrete ecological barrier between open ocean conditions and the many bays, fjords and inlets characterizing the Alaska coast. We examined nutrient and chlorophyll-a concentrations from bottle samples collected between 0 - 270 m depths in the Alaska Coastal Current (ACC) on 56 cruises along multiple transects in the northern Gulf of Alaska between Prince William Sound and Kodiak Island from 1998-2010 to determine average monthly concentrations of the macronutrients (N, P, and Si) and to assess interannual variability in the timing and extent of nutrient drawdown. Nutrient concentrations in the surface waters of the ACC follow a remarkably consistent annual cycle whereby winter nitrate levels peak in March around 14 micromolar and are completely depleted (< 1 micromolar) in the top 10m from July through October along the entire length of the ACC studied. Chlorophyll-a concentrations are highest during the spring drawdown in April and May but persist at significant levels throughout the summer and fall despite surface nutrient depletion. The timing of the spring bloom shows significant interannual variability, often occurring before stratification of the mixed layer, and consistently starting earlier in the ACC than over the mid- and outer- continental shelf and slope. The extent of spring and summer nutrient drawdown is notable for its uniformity over the length of the ACC studied with minimal along-shore gradients, indicating that advection processes may not be as significant as regional climatology with regard to patterns of primary production.

A Novel Technique for Measuring Zooplankton Abundance

Jessica Pretty, Jessica Turner, Andrew McDonnell

Presenter: Jessica Pretty

Email: jlpretty@alaska.edu

Can optical instruments facilitate collection of zooplankton distribution comparable to historically used techniques? This poster will outline the technique of utilizing an Underwater Vision Profiler (UVP) in quantitative identification of zooplankton. The UVP takes images of measured parcels of water throughout a CTD cast and separates particles and plankton found within the image to allow for sorting by the plankton identification program Zooprocess. This technique will enrich information on zooplankton vertical distribution at a finer scale than is available using net towing techniques. This discussion will focus on data gathered aboard the July 2015 Gulf of Alaska ocean-acidification cruise, comparing zooplankton abundance found by bongo-net tow and UVP-imaging techniques. The goal of this project is to discuss how optical representations of zooplankton in the water column can be utilized in lieu of and in addition to traditional zooplankton sampling techniques.

From Cool to Hot: 2012-2015 Transition in Kachemak Bay and Cook Inlet Alaska Waters

Kristine Holderied, Dominic Hondolero, Tammy Neher, Angela Doroff

Presenter: Kristine Holderied

Email: kris.holderied@noaa.gov

Coastal waters in Kachemak Bay and Cook Inlet Alaska transitioned from cooler to much warmer than average conditions in the fall of 2013, as part of the warm anomaly observed across the eastern Pacific Ocean and Bering Sea. Large changes were not observed in coastal marine species in 2014, but dramatic biological responses were observed in 2015, with early and more intense blooms of Pseudo-nitzschia phytoplankton species, unusual numbers of humpback whales feeding in Kachemak Bay for most of the summer, increased numbers of king salmon, increased seabird and sea otter deaths and commercial mariculture closures in parts of Kachemak Bay due to a paralytic shellfish poisoning event. Atmospheric warming can affect Kachemak Bay and Cook Inlet water temperatures, change the amount and timing of freshwater input from precipitation, snowpack and glacial melt, and affect upwelling from the adjacent Gulf of Alaska shelf due to changes in the Alaska Coastal Current. The transition in marine conditions was observed with oceanographic and plankton monitoring conducted in Kachemak Bay and lower Cook Inlet as part of the Gulf Watch Alaska ecosystem monitoring program funded by the Exxon Valdez oil spill Trustee Council. We summarize the oceanographic patterns observed from conductivity-temperature-depth (CTD) profiler stations along shipboard transects in Kachemak Bay and lower Cook Inlet (2012-2015) and from continuous observations at the Kachemak Bay National Estuarine Research Reserve water quality station at Seldovia harbor (2004-2015). Average monthly water temperatures were above normal for most months in 2014 and 2015 and were warmer than at any time since 2005. While near-shore temperatures transitioned from 1 to 2 degrees C below average (relative to the past decade) in 2012 to up to 2.5 degrees C above the average in 2014-2015, salinity anomalies were more variable. The persistence of warm conditions in estuarine waters, as well as on the adjacent shelf, can be used to help explain changes in the timing and composition of phytoplankton blooms and how changes in primary production may be affecting zooplankton, forage fish and apex marine predators in Kachemak Bay and Cook Inlet.

Recommendations for the Use of Unmanned Aircraft Systems in Intertidal Surveys

Brenda Konar, Katrin Iken

Presenter: Brenda Konar

Email: bhkonar@alaska.edu

In the Gulf of Alaska, several intertidal monitoring efforts have recently combined under the Gulf Watch Alaska program (EVOS-funded, http://www.aoos.org/gulfwatchalaska/) to establish and continue the efforts for monitoring intertidal communities. One of the shortfalls of the type of sampling currently being conducted by this program is the small area that can be feasibly monitored with limited people-power and time due to low tide series. What is needed is a cost-effective mechanism that can be used to survey larger areas during the short low tide time period. Here, we tested the use of unmanned aircraft systems (UAS) as a cost-effective tool to expand the small-scale (on the order of meters) with larger-scale (on the order of kilometers) monitoring. Specifically, we are testing if imagery from low-flying UAS can be used to monitor intertidal seagrass and rocky systems in Kachemak Bay. Comparisons of UAS imagery to photos taken by observers in the intertidal show that resulting data are comparable. However, data taken immediately in the field have higher resolution than either the UAS imagery or the observer photos. This lower resolution (both by UAS and observer) may be remedied with a higher resolution camera but more tests are required to determine the type of camera needed. We show that UAS surveys are valuable depending on the question being asked and the taxonomic resolution needed.

Calculating a Spatially-Explicit Index of Predation to Improve the Stock Assessment for Walleye Pollock (*Gadus chalcogrammus*) in the Gulf of Alaska

Cheryl L. Barnes, Anne H. Beaudreau, Mary E. Hunsicker, Martin W. Dorn, Kirstin K. Holsman, Lorenzo Ciannelli

Presenter: Cheryl L. Barnes

Email: cheryl.barnes@alaska.edu

Walleye Pollock (*Gadus chalcogrammus*) plays an integral role in the trophic ecology of both the Eastern Bering Sea and Gulf of Alaska. Pollock are also a vital component of the regions' socioeconomics, supporting one of the largest and most valuable fisheries in the world. Therefore, it is important to understand variability in the population dynamics of pollock to maintain sustainable harvest practices through time and space. Although predation mortality is known to have considerable impacts on the size and age structure of pollock, it is not explicitly accounted for within the stock assessment framework designed for the Gulf of Alaska. Using food habits data collected by the NOAA Alaska Fisheries Science Center (1981 to 2011), we have calculated an index of predation for Walleye Pollock that accounts for spatial variation in consumption by four major groundfish predators (i.e., Arrowtooth Flounder [*Atheresthes stomias*], Pacific Cod [*Gadus macrocephalus*], Pacific Halibut [*Hippoglossus stenolepis*], and Walleye Pollock conspecifics). This index will be made available for use as a modifier of constant natural mortality in future stock assessment models. Continuing analyses will evaluate spatiotemporal variation in the predation index related to various environmental and demographic factors. This collaborative study is a first-step toward augmenting the single species approach to pollock management in the Gulf of Alaska by incorporating available ecological information into model parameterization.

Epipelagic Predation on Young of the Year Groundfish in the Gulf of Alaska

Casey Debenham, Wyatt Fournier, and Jared Weems

Presenter: Casey Debenham

Email: casey.debenham@noaa.gov

The Gulf of Alaska Project (GOAIERP) and the Gulf of Alaska Assessment (GOAA) surveys are integrated ecosystem studies that examine the physical and biological mechanisms, which determine the survival of commercially important young-of-the-year (YOY) groundfish in the Gulf of Alaska, specifically Walleye Pollock, Pacific Cod, Pacific Ocean Perch, Sablefish and Arrowtooth Flounder. The predation pressure faced by these species while they inhabit the water column during their early life history was examined by analyzing the stomach contents and co-occurrence of several epipelagic predators, including Coho salmon, Pink Salmon and Pacific Pomfret. Coho salmon preyed on Gadids, which accounted for up to 25% of their diet. In 2014 and 2015 Coho salmon also preyed heavily upon Sablefish. This corresponds with what appears to be successfully age-0 recruitment events. Pink salmon are more of an opportunistic predator, with their diet being both planktonic and piscivorous. During the survey Pink salmon had low overall percentages of focal fish, such as rockfish, in their diet. By extrapolating the surveys catch numbers to the returning Southeast Alaska Pink salmon biomass, it is suggested that Pink salmon can account for the removal of upwards of 11 million age-0 rockfish from the Gulf of Alaska ecosystem. During the 2014 & 2015 survey years an increase in the number of Pacific Pomfret, an offshore pelagic predator, was observed. This increase in Pomfret correlated with an increased sea surface temperature. Based on personal observations and preliminary results it appears that Pomfret preyed primarily on squid, sablefish, and rockfish. Despite the predation of YOY rockfish by Pomfret the catch distributions of and co-occurrence of YOY Rockfish and Pacific Pomfret appear to be negatively correlated. This study starts to explore and examine the pelagic predation pressure exerted on the commercially important YOY groundfish in Southeast Alaska. This illustrates the importance and unique opportunities provided by longer term studies such as GOAIERP and GOAA.

Updates of Key Metrics from Long-term Monitoring of Nearshore Marine Ecosystems in the Gulf of Alaska: Detecting Change and Understanding Cause

Heather Coletti, Dan Esler, Brenda Ballachey, James Bodkin, Thomas Dean, George Esslinger, Katrin Iken, Kimberly Kloecker, Brenda Konar, Mandy Lindeberg, Dan Monson, Benjamin Weitzman

Presenter: Heather Coletti

Email: Heather_Coletti@nps.gov

Nearshore marine habitats support unique and valued ecosystem services, and are components of long-term monitoring efforts conducted by the National Park Service Southwest Alaska Network, University of Alaska Fairbanks, and most recently Gulf Watch Alaska (funded by the Exxon Valdez Oil Spill Trustee Council). 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 apex consumers, while simultaneously monitoring metrics such as density and size distributions associated with the primary producers and primary consumers, will help identify potential causes of change and guide management activity. 2015 marks our ninth year of field data collection for several metrics. Here, we describe the ongoing monitoring of the nearshore food web components and identify ways in which monitoring at a variety of spatial scales can provide understanding into the magnitude and causes of change within and across ecosystems. We provide updates to key metrics and interpretation of results to date. We also highlight the additional benefits of a long-term monitoring program, such as providing baseline data in the event of an oil spill or vessel grounding, and tracking invasive species or the spread of disease.

Evaluation of Nearshore Communities and Habitats in Lower Cook Inlet

Heather Coletti, Katrin Iken, Tahzay Jones, Brenda Konar, Mandy Lindeberg, Susan Saupe, Sarah Venator, Catherine Coon

Presenter: Heather Coletti

Email: Heather_Coletti@nps.gov

The Cook Inlet Planning Area is one of the Bureau of Ocean Energy Management's (BOEM) Proposed Final Outer Continental Shelf Oil & Gas Leasing Program 2012-2017 lease sale. A National Environmental Policy Act (NEPA) analysis of the area has not occurred since 2003 and BOEM has provided funding to update information regarding the area's physical and biological environment. The focus of this work is in the nearshore area - specifically lower Cook Inlet intertidal and shallow subtidal benthic habitat downstream of any activities associated with the proposed Cook Inlet Lease Area. Work in 2015 began with a compilation of existing nearshore study reports and sampling locations for lower Cook Inlet into a publically available visual database that can be used for planning and permitting processes. The project also included field reconnaissance surveys for intertidal and shallow subtidal rocky habitats in western lower Cook Inlet, which were selected through queries of the Alaska ShoreZone habitat database. Intertidal habitat was relatively geomorphically unique, wide, low-angle bedrock and boulder ramps in areas potentially at risk from oil spills. Seaweed and invertebrate assemblages were assessed at six intertidal sites and 18 subtidal sites. Sampling the complex tidal zonation patterns included the use of Real-time Kinetic (RTK) survey methods that can resolve slight changes in tidal height. Detailed topographic maps are presented for each intertidal site, along with quantitative species data for intertidal and subtidal sites. In addition, intertidal communities were assessed using across shore transects with randomly placed quadrats for percent cover estimates. Subtidal communities were sampled visually (% cover) and biomass and abundance determined from collections. Subtidal community characteristics had a distinct north to south pattern along the study area. Our next steps include developing a formal workplan for the next four years to describe, assess, monitor, and/or quantify various habitat strata in lower Cook Inlet. Results from this work will be used in NEPA analyses and other documents required for the upcoming lease sale or future exploration and development associated with the sale.

Recent Survey Confirms Persistence of Lingering Oil 26 Years after the *Exxon Valdez* Oil Spill

Corey Fugate, Mandy Lindeberg, Mark Carls, Jacek Maselko

Presenter: Corey Fugate

Email: corey.fugate@noaa.gov

Alaska North Slope crude oil remains in some beaches in western Prince William Sound (PWS) 26 years after the 1989 *Exxon Valdez* Oil Spill (EVOS). This oil remains below the surface of some beaches despite unprecedented clean-up efforts, multiple sampling and remediation attempts, tidal inundation, wave energy, and other weathering processes. A long-term monitoring effort for lingering oil in PWS was launched by the Gulf Watch Alaska program funded through the EVOS Trustee Council. In 2015, 400 pits were dug at nine beaches with known oil deposits to assess the quantity, weathering, and bioavailability of lingering oil. This sampling extends the time series formed from similar survey efforts which began in 2001. Lingering oil was found on six of the nine beaches surveyed with oil covering up to 30% on one of the sites. Passive samplers deployed for 10 days on one of the most contaminated beaches revealed no evidence that the buried oil is biologically available, and further indicates that little oil weathering is occurring. The lack of weathering is consistent with earlier observations and we expect this will be confirmed by oil analyses now in progress. Lack of weathering and quantities of remaining oil indicates that the rate at which it is being lost from these beaches is very low, hence the oil is likely to remain for many more years.

Response of Top Predators and Prey to Changes in the Marine Environment: Gulf Watch Alaska's Pelagic Monitoring Program

Mandy Lindeberg, Mayumi Arimitsu, Mary Anne Bishop, Dan Cushing, Rob Kaler, Kathy Kuletz, Craig Matkin, John Moran, John Piatt, Jan Straley

Presenter: Mandy Lindeberg

Email: mandy.lindeberg@noaa.gov

Pelagic marine ecosystems are periodically subjected to disturbances of such a magnitude as to significantly alter predator and prey communities. Gulf Watch Alaska (GWA) is a long-term monitoring program established to track recovery of populations injured from the *Exxon Valdez* Oil Spill (EVOS). GWA partnerships leverage an extensive monitoring effort to collect information on environmental conditions and biological resources, in turn facilitating interpretation of future community changes. The GWA team monitor changes in whales, forage fish and marine birds. Killer whale and marine bird studies include legacy datasets spanning 25+ years while other studies were initiated in 2012. Key findings to date can be summarized as follows: *Killer whales* – Trajectories of three ecotypes of killer whales demonstrate differing sensitivities to perturbations in this long-lived species. The long-term consequences of EVOS for one population of Biggs (transient) killer whales has resulted in an accelerated extinction. *Humpback whales*– Recent removals of herring in Prince William Sound (PWS) by humpback whales approximated the biomass equivalent to the most recent herring fishery harvest (1998). Humpback whale predation on herring in PWS can exert top-down pressure on herring but this may change as fish communities change. *Forage fish*– Drawing upon past efforts in PWS to study small-schooling fish such as capelin, sand lance, and herring, we developed a survey design that combines aerial and hydroacoustic-trawl surveys. Work has focused on validation of aerial observations, ground-truthing hydroacoustic signals, and documenting marine habitat of primary prey species in PWS. *Marine birds* – During mid-summer, many marine bird taxa associated with coastal and offshore habitats declined in abundance over a period of two decades, while few taxa associated with shoreline habitats declined, and several increased. Densities of the most abundant marine birds in PWS varied significantly between early and late winter, suggesting multiple surveys are required to quantify the distribution and abundance of wintering populations. Continued monitoring of trends in predator and prey populations will be key in understanding changes in PWS's pelagic ecosystem and how recent anomalies and future climate change may impact these populations.

Mesoscale Ecosystem Processes in the Gulf of Alaska

Lisa Sztukowski, Suresh Sethi, Tuula Hollmen

Presenter: Lisa Sztukowski

Email: lisas@alaskasealife.org

In response to major ecological perturbations (1964 earthquake and 1989 Exxon Valdez oil spill) and basin-scale oceanographic shifts in the Gulf of Alaska, substantial research effort has been expended to improve understanding about the structure and spatiotemporal dynamics of the Gulf of Alaska ecosystem. High natural variability and high costs of sampling in the marine environment have led to challenges in synthesizing understanding about the Gulf of Alaska system, however, conceptual modeling may provide a useful tool to facilitate these efforts. Conceptual ecological models synthesize information about complex systems into visual frameworks which promote understanding, communication and offer guidance to future research. We use this tool to examine mesoscale mechanisms shaping ecosystem structure, function, and drivers of change in Gulf of Alaska focusing on top down forcing, bottom up processes, and ecological linchpin (key trophic element) hypotheses. Our conceptual modeling methods combine quantitative and qualitative data using expert knowledge to select key components, and assess linkages, uncertainty, and variability. Key to this process are clearly defined objectives, defined spatial and temporal boundaries, and decisions on the currency of the system (e.g. energy transfer). These conceptual ecological models will be used to integrate the current state of knowledge within the ecosystem, and to identify data gaps and high-priority areas for research. Ultimately the models will provide the basis for development of causal hypotheses between environmental or anthropogenic stressors and ecological effects; thus these models will facilitate thought exercises and simple simulations of management and conservation interest.

Marine Debris in Five National Parks in Alaska

Lori Polasek, Janet Bering, Sharon Kim, Peter Neitlich, Benjamin Pister, Miranda Terwilliger, Carissa Turner

Presenter: Lori Polasek

Email: lorip@alaskasealife.org

The main goal of this project was to remove as much marine debris as possible from five coastal National Park Service units in Alaska. Documentation of debris collection was a secondary goal and therefore data collection was designed to be as efficient as possible. Approximately 80 kilometers of coastline were cleaned with over 10,000 kg of debris collected. Marine debris was found on every beach surveyed. Hard plastic were found on all beaches. Foam was found at every beach except one. Rope/netting was the next most commonly found category, present at 23 out of 28 beaches. Overall, hard plastic contributed to 60 percent of the total weight of debris. Rope/netting (14.6%) was a greater proportion of the weight from all beaches than foam (13.3%). Non-ferrous metal contributed the smallest amount of debris by weight (1.7%). This study collected debris across a wide range of Alaska's coastline. The work is just the beginning as a baseline data set that collected debris in both the Western Arctic and the Gulf of Alaska within one season. With the changing climate, exploration, and vessel traffic, especially in the Western Arctic, there needs to be a planned effort to repeat this work to track changes on, and impact to, the Alaskan coast.

Changing Tides – The Convergence of Intertidal Invertebrates, Bears and People

Heather Coletti, Grant Hildebrand, Jim Pfeiffenberger, Carissa Turner, Brenda Ballachey, Liz Bowen, Kaiti Chritz, Katrina Counihan, Joy Erlenbach, Dan Esler, Tuula Hollmen, Dave Gustine, Buck Mangipane, Benjamin Pister, Charlie Robbins, Tammy Wilson

Presenter: Heather Coletti

Email: Heather_Coletti@nps.gov

National Parks in Southwest Alaska are facing a myriad of management concerns that were previously unknown for these remote coasts, including increasing visitation, expanded commercial and industrial development, and environmental changes due to natural and anthropogenic forces. These are concerns because of their potential to significantly degrade and impair resources in coastal systems. Change is inevitable and understanding these systems is paramount to the National Park Service's ability to carry out the mission of maintaining healthy ecosystems for future generations. Identifying relationships between species inhabiting coastal and terrestrial ecosystems, and between wildlife and park visitors, will enhance our knowledge of these systems and inform management decisions related to mitigating impacts of human-caused changes. Further, this knowledge will allow NPS to educate and manage visitors coming to coastal areas to harvest marine invertebrates or view wildlife. In 2015, we initiated the "Changing Tides" project with three key components: (1) brown bear fitness and use of marine resources, (2) health of bivalves (clams and mussels), and (3) an integrated outreach program. In our first year, brown bears in Katmai National Park and Preserve were captured and GPS collared to examine overall health, assess their use of coastal areas, and obtain direct foraging observations to quantify their reliance on marine food resources. We also collected a variety of bivalve species from the coasts of Katmai and Lake Clark National Parks and Preserves. Several specimens were kept live in small aquarium-like containers, and condition and performance metrics were assessed in the laboratory. Others are being used to perform genetic transcription diagnostics (gene expression) to measure the physiologic responses of individuals to stressors. Prior to the field season, we began development of outreach materials to connect visitors and the broader public to the research program, including resources of concern and anthropogenic drivers potentially influencing those resources. Outreach materials were continually updated over the course of the summer and distributed via public meetings, web sites, blogs, and social media. This project will increase our understanding of how various stressors may affect both marine intertidal invertebrates and bear populations at multiple spatial and temporal scales.

Variability in Sea Urchin Population Size Structure at Multiple Spatial Scales across the Aleutian Islands: implications for Sea Otters

Benjamin Weitzman, Brenda Konar, Tim Tinker, Daniel Esler, Mike Kenner, James Estes

Presenter: Benjamin Weitzman

Email: bweitzman@usgs.gov

Sea otter diets in the Aleutian Islands are dominated by a single species of sea urchin (*Strongylocentrotus polyacanthus*). Sea urchin population dynamics in the Aleutian Islands have been observed for nearly 40 years; however our understanding of spatial and temporal patterns of variability in urchin productivity and how this relates to sea otter population dynamics is unknown. Sea otter populations often are limited by prey resources and thus high urchin productivity likely contributed to historically high densities of sea otters in the Aleutians. Variation in urchin productivity has important implications for determining dynamics of sea otter populations, including differences in potential carrying capacities across the region. Here we describe patterns of variability in sea urchin recruitment and growth, at various spatial scales over time. Since the 1980s, we have conducted systematic surveys of abundance and size of sea urchins at >250sites, spread over 20 islands across the Aleutian Archipelago. Here, we used these data to generate sea urchin size frequency distributions at spatial scales of site, island, island group, and region, in order to evaluate patterns of recruitment and growth in sea urchin populations. Understanding contemporary and historical variation in sea urchin productivity contributes to predictions about how this resource will respond to changing environmental conditions, such as ocean warming and acidification, and in turn how this may influence nearshore predators like sea otters.

Volunteer Photographers Update Images of Trends in Marine Life on Western Prince William Sound Shorelines: 1989 to 2015

Rob Campbell, Kate McLaughlin, George Esslinger, Scott Pegau, David Janka, Pamela Eiting, Alan Mearns

Presenter: Alan Mearns

Email: alan.mearns@noaa.gov

In 1989 scientists began monitoring and photographing inter-tidal marine life on rocky shorelines in western Prince William Sound. Staff of NOAA's Emergency Response Division (ERD) took over monitoring in 1990 and continued to 2000. From 2001 to 2012 the lead author continued visiting and photographing up to 9 sites. Monitoring included landscape-scale photographs of oiled, oiled and cleaned and unoiled sites. In 2012 volunteers began taking over site visits. In 2015 volunteers visited the sites, providing images used by the lead author to estimate longterm trends in cover of seaweeds, mussels and barnacles. The images and plots reveal 4 to 10 year episodes of high and low abundance. In 2015 most of the sites showed a decline in cover of seaweed and mussels, terminating the fourth such episode in 26 years. At all sites percent cover of rockweed and or mussels has ranged from less than 5% to nearly 100%. A multi-layered thick bed of mussels that occurred on a tombolo at Mussel Beach in Upper Passage disappeared in the early 1990s and has not yet "recovered" as of 2015, marking a 20 year absence. This volunteer photo monitoring compliments other past and ongoing intertidal monitoring surveys adding to our understanding of the huge biological variability that apparently occurs in the Prince William Sound intertidal.

Giant Kelp (*Macrocystis pyrifera*) and Coastal Resilience: A New Long-term Monitoring Project in Sitka Sound, Alaska

Karisa Maurer, Aimee Valencia, Lauren Bell, Lucy Vlietstra, Karina Mrakovcich

Presenter: Karisa Maurer

Email: karisa.l.maurer@uscga.edu

Canopy forming kelps provide a key habitat for many marine species, including those of commercial importance, and they serve an important role in coastal resilience by buffering coastal communities from storms. In northern latitudes, where climate change impacts are projected to be most pronounced, understanding factors that contribute to, or inhibit, kelp growth will be critical to the management and stewardship of coastal resources in these regions. In June 2015, the U.S. Coast Guard Academy and Sitka Sound Science Center initiated a long-term study to monitor the relationship between the spatial extent of giant kelp canopy coverand specific environmental variables in Sitka Sound, southeast Alaska. Specifically, we established five permanent sites – three within existing kelp beds and two in areas without kelp (control sites), and we monitored kelp bed size (m^2), water temperature (C°), salinity, and pH. Short-term temporal and spatial changes in kelp bed size were monitored by recording lat-lon coordinates around the perimeter of the surface canopy during the two lowest tides of June and July 2015 and plotting the spatial extent of kelp at each site in ArcGIS. To compare changes in canopy extent to environmental conditions, temperature and salinity of these sites were continuously monitored with a combination of Hobo TidbiTv2 and Hobo Conductivity loggers deployed at the surface and benthos at each site. In addition, water column profiles of temperature, salinity and pH were taken with a conductivity-temperature-depth meter (YSI 6500) twice a week during a 6-week period. Overall, kelp canopy extent on 22 June ranged from 2756 m^2 to 5654 m^2 among the three sites, with relatively small reductions in size (6.6-12.2%) when measurements were repeated on 20 July. Although no major differences in sea surface temperature (SST), salinity, or pH were detected between kelp and control sites during the first few weeks of the study (SST: 13.1-15.2°C; salinity 11.0-13.0 ppt, pH: 8.1-8.6), environmental loggers will continue to collect temperature, salinity, and pH data year-round. In addition, surface kelp canopy extent will be monitored throughout the summer growing season in coming years.

Nearshore Fish Ecology of the Gulf of Alaska

Olav Ormseth, Kimberly Rand

Presenter: Olav Ormseth

Email: olav.ormseth@noaa.gov

As part of the Gulf of Alaska Integrated Ecosystem Research Program (GOAIERP), we sampled fish in nearshore areas within nine bays in the eastern and western sides of the GOA during 2011 and 2013. The bays varied widely in their geographical extent, predominant habitats, and exposure to offshore waters. Sampling was conducted during April, July, and September in the eastern GOA and May, August, and October/November in the western GOA. We used a 16 ft inflatable boat to deploy a ~15m diameter purse seine, pursing and retrieving the net by hand. Sampling was limited to depths of 20 ft. and shallower to ensure that the lower edge of the net contacted the bottom. Sampling sites were also chosen based on the presence of vegetative physical structure attached to the seafloor (e.g. eelgrass, *Laminaria* kelp) as identified using a skiff-mounted echosounder and visual observation. At each sampling site we measured temperature and salinity, and when possible we deployed an underwater video camera to verify habitat type. The species composition of and abundance in catches varied within and among the sites, as well as with season and year. For all areas, species composition changed more dramatically from spring to summer than from summer to fall. In 2011 age-zero Pacific cod and pollock were abundant in summer catches in the western GOA, and to a lesser extent in eastern GOA summer catches and gulfwide fall catches. In 2013, very few pollock were observed in catches and Pacific cod abundance was lower than in 2011. Juvenile rockfish were encountered more frequently in the eastern GOA. While some species appeared to have a strong preference for one type of vegetative habitat, the distribution of juvenile fishes seemed to be less dependent on small-scale habitat features and more influenced by large-scale geographic patterns within bays. Abundance of fishes was greater in the western GOA.

Applications of RTK to Intertidal Floral and Faunal Assessments in Lower Cook Inlet, Alaska

Tahzay Jones, Sarah Venator, Mandy Lindeberg, Susan Saupe

Presenter: Tahzay Jones

Email: tahzay_jones@nps.gov

In June 2015, Real Time Kinetic (RTK) GPS surveys were conducted in concert with intertidal surveys to accurately measure species distributions along elevation gradients within the intertidal zone in western lower Cook Inlet, Alaska. Generally, intertidal surveys rely on gross elevational categorizations based on field interpretations of the biological assemblages present, an acceptable practice when there is clear stratification on steeper sloping beaches. RTK is particularly useful for habitats that have low slopes such as, the extensive wide rock ramps in Lower Cook Inlet where elevation gradients are difficult to determine. RTK provides for positional locations in the X, Y, and Z planes to centimeter-level accuracy based on the geoid model of the earth. Using RTK enables accurate assessment of the topography of the site being surveyed, and allows for comparative assessments of actual elevation of biological distribution within and among sites. However, when comparing among sites, mean sea level is not always found at the same elevation relative to the geoid across large distances. Thus, the biological assemblages at identical geoid elevations do not necessarily experience the same relative sea level, nor are they subject to the same associated tidal dynamics. However, site-specific species assemblages measured with RTK, along with measurements of the low tide water location, can indicate a species distribution range within a site, and once a relative zero tidal height is known, the data can be assessed by shifting the species elevation locations to relative MSL for a site.

Multi-agency Efforts to Monitor Sea Star Wasting Disease in Alaska: Results and Recommendations for Future Efforts

Benjamin Pister, Brenda Ballachey, Heather Coletti, Thomas Dean, Katrin Iken, Brenda Konar, Erin Kunisch, Mandy Lindeberg, and Benjamin Weitzman

Presenter: Benjamin Pister

Email: benjamin_pister@nps.gov

Sea stars play a vital ecological role in shaping nearshore benthic ecosystems as top-level predators. The absence of sea stars can lead to their prey, such as mussels and urchins, multiplying and driving out other nearshore inhabitants. Since 2013 a sea star wasting disease has infected at least 20 different sea star species and decimated populations along the west coast of North America from Baja California, Mexico to Sitka, Alaska. Here we present the collective results from two years of systematic surveys conducted in Alaska by the National Park Service, United States Geological Survey, University of Alaska, Fairbanks (coordinating as part of the Gulf Watch Alaska program) and the National Oceanic and Atmospheric Administration. Our surveys encompass intertidal monitoring sites within Prince William Sound, Kenai Fjords National Park, Kachemak Bay, Katmai National Park and Preserve, and subtidal sites in the Aleutians. Within our surveys we observed low occurrences of the sea star wasting disease at both subtidal and intertidal monitoring sites. Disease prevalence was primarily limited to Kachemak Bay, where infection rates were between 0-27% depending on species and site, with highest frequency of occurrence in Evasterias troschelii, and an overall mean infection rate of 5.7%. Less than 1% of sea stars observed in other areas were infected. These infection rates are much lower than the epidemic proportions observed at monitoring sites in other Pacific states, Canada and southeast Alaska. However, most of our surveys were limited to the intertidal, and our survey sites, though widespread, as a whole represent a small fraction of available sea star habitat. Diseased sea stars were occasionally observed outside of our surveys, when none were recorded during the surveys. Anecdotal observations and citizen science initiatives could be a useful tool in documenting the occurrence and prevalence of the disease. Careful examination of diseased sea stars is required, however, to avoid misidentification of infected stars. We urge the Alaskan marine science community to aid citizen scientists in the rigorous observation and identification of infected sea stars to help track wasting disease.

Epipelagic Predation on Young of the Year Groundfish in the Gulf of Alaska

Casey Debenham, Wyatt Fournier, Jared Weems

Presenter: Casey Debenham

Email: casey.debenham@noaa.gov

The Gulf of Alaska Project (GOAIERP) and the Gulf of Alaska Assessment (GOAA) surveys are integrated ecosystem studies that examine the physical and biological mechanisms, which determine the survival of commercially important young-of-the-year (YOY) groundfish in the Gulf of Alaska, specifically Walleye Pollock, Pacific Cod, Pacific Ocean Perch, Sablefish and Arrowtooth Flounder. The predation pressure faced by these species while they inhabit the water column during their early life history was examined by analyzing the stomach contents and co-occurrence of several epipelagic predators, including Coho salmon, Pink Salmon and Pacific Pomfret. Coho salmon preyed on Gadids, which accounted for up to 25% of their diet. In 2014 and 2015 Coho salmon also preyed heavily upon Sablefish. This corresponds with what appears to be successfully age-0 recruitment events. Pink salmon are more of an opportunistic predator, with their diet being both planktonic and piscivorous. During the survey Pink salmon had low overall percentages of focal fish, such as rockfish, in their diet. By extrapolating the surveys catch numbers to the returning Southeast Alaska Pink salmon biomass, it is suggested that Pink salmon can account for the removal of upwards of 11 million age-0 rockfish from the Gulf of Alaska ecosystem. During the 2014 & 2015 survey years an increase in the number of Pacific Pomfret, an offshore pelagic predator, was observed. This increase in Pomfret correlated with an increased sea surface temperature. Based on personal observations and preliminary results it appears that Pomfret preyed primarily on squid, sablefish, and rockfish. Despite the predation of YOY rockfish by Pomfret the catch distributions of and co-occurrence of YOY Rockfish and Pacific Pomfret appear to be negatively correlated. This study starts to explore and examine the pelagic predation pressure exerted on the commercially important YOY groundfish in Southeast Alaska. This illustrates the importance and unique opportunities provided by longer term studies such as GOAIERP and GOAA.

Inter-annual Variability in the Prey Quality of Planktivores in the Gulf of Alaska in 2013 to 2015

Emily Fergusson, Ron Heintz, Corey Fugate

Presenter: Emily Fergusson

Email: emily.fergusson@noaa.gov

Zooplankton are an important prey resource to many marine planktivorous fish, and changes to the quality of the zooplankton would directly affect the nutritional status of their predators. Energy density and lipid content was measured for preferred prey of Gulf of Alaska planktivorous fish including juvenile salmon, rockfish, and pollock from the summer of 2013 and 2014, the energy density of these predators was also measured. There was significant interannual variability in the quality of the prey. Energy density of the preferred prey was 2- to 3-fold higher in 2014 compared to 2013. Where the lipid content of the large copepod, *C. marshallae*, was comparable to most euphausiids (*Thysanoessa sp.*), the lipid content of stage CV *C. marshallae* was 4-times higher than that of stage CVI females (adults). Water temperatures in 2014 were anomalously warm and some zooplanktivorous species were notably large. These data reveal a mechanism by which physical factors directly influence a marine ecosystem.

Monitoring Pinto Abalone in Sitka Sound, Alaska

Mike Donnellan, Lauren Bell, Taylor White, Kyle Hebert, Victoria O'Connell, Pete Raimondi

Presenter: Lauren Bell

Email: lbell@sitkascience.org

In Southeast Alaska, the northernmost range of pinto abalone (*Haliotis kamtschatkana*), a commercial fishery began in the 1960's and abalone were harvested extensively from the 1970's until 1996 when the fishery was closed due to a severe decrease in total catch. Changing environmental conditions and increased predation pressure on pinto abalone from an expanding population of Northern sea otters have since been cited as factors preventing recovery of these abalone. In 2004 pinto abalone were designated a "Species of Concern" by the National Marine Fisheries Service. However, stock status of pinto abalone in Alaska is largely unknown due to lack of population assessments, which was cited as a fundamental knowledge gap in the 2014 decision to not list pinto abalone as "Threatened" or "Endangered" under the Endangered Species Act. Lacking basic information such as estimates of density, size and aggregation distribution, harvest limits for ongoing personal use and subsistence fisheries were set with only an assumption of sustainability, rather than based on scientifically supported results. In response to these concerns, biologists from the Alaska Department of Fish and Game and the Sitka Sound Science Center collaborated to develop a long-term monitoring plan for pinto abalone in Sitka Sound, Alaska. Two 30 x 2 m subtidal transects were permanently established at each of eight sites in the summer of 2015, and abalone density, size, exposure, and habitat were recorded during repeated dive surveys of these transects. Artificial Recruitment Modules, built from modified crab pots filled with bricks, were deployed at each transect, with the goal of quantifying recruitment to the local population. Here, we present our site selection methodology, survey protocols, and initial findings from this first season of sampling. Ongoing monitoring of these sites will occur twice yearly, with a subset of high-density sites chosen for more frequent (up to bi-monthly) monitoring. Our intent is that the results of this study will inform Alaska's future management of this species and serve as a pilot project for surveys that may cover the geographic extent of pinto abalone in Alaska.

Surveying Euphausiid Abundance to Understand the Central Gulf of Alaska Ecosystem

Patrick Ressler, Kirsten Simonsen, Chris Rooper, Martin Dorn, Stephani Zador

Presenter: Patrick Ressler

Email: patrick.ressler@noaa.gov

Euphausiids (or 'krill') are a key zooplankton taxon in the Gulf of Alaska (GOA), as in other ecosystems around the world. They form an important ecological link between primary production and higher trophic levels as prey for marine mammals, seabirds, and fish. We created an index of euphausiid (principally *Thysanoessa* spp.) abundance in the central GOA using data from four summertime acoustic-trawl surveys of walleye pollock (*Gadus chalcogrammus*) conducted between 2003 and 2013, identifying euphausiid backscatter using relative frequency response and targeted trawling. Our results show that survey methods developed in the eastern Bering Sea (EBS) are applicable and effective in the GOA. Euphausiid abundance tended to be greater in coastal bays and troughs around Kodiak Island than on the remainder of the shelf. Highest euphausiid abundance was observed in 2011 as compared to other years in the time series. The euphausiid abundance data from these surveys have broad application in research and management. For example, we used generalized additive models (GAMs) to examine the relationship between relative euphausiid abundance and several potential predictors including pollock abundance, temperature, bottom depth, and primary production. GAM results from the GOA were compared to an updated GAM of euphausiid abundance from the eastern Bering Sea to determine if the factors driving abundance and distribution were similar in both systems. Temperature was not a strong predictor of euphausiid abundance in the GOA, though it was in the EBS; the generally warmer temperatures and lack of seasonal ice cover in the GOA may be a key difference between these ecosystems. Pollock abundance was a statistically significant but not strongly negative predictor of euphausiid abundance in models of both systems, a result not consistent with top-down control of euphausiid abundance by pollock predation. We are also examining predator-prey relationships with other zooplanktivorous fishes in the GOA using these data. Finally, annual indices of euphausiid abundance are being considered in stock assessments for GOA pollock and assessment of GOA ecosystem status.

Gulf of Alaska Integrated Ecosystem Research Program: Ichthyoplankton Diversity in the Eastern and Western Gulf of Alaska during the Spring and Summer of 2011 and 2013

Deborah Blood, Ann Matarese, Elizabeth Siddon, Jessica Randall

Presenter: Deborah Blood

Email: Debbie.Blood@noaa.gov

The Gulf of Alaska Integrated Ecosystem Research Program (GOA-IERP) is a multi-disciplinary study examining interactions between physical and biological oceanography to understand how the environment influences the survival of early life history stages and recruitment of selected commercially and ecologically important groundfishes. Biological and oceanographic surveys in the eastern (east of Prince William Sound) and western (near Kodiak Island) Gulf of Alaska (GOA) were conducted during spring and summer of 2011 and 2013. While the emphasis of the program is on the distribution and abundance of selected focal species, understanding ecological processes through species diversity and structure of the entire ichthyoplankton assemblage helps inform those species-specific patterns. Fish early life history patterns are well-described for the western GOA, but ichthyoplankton patterns and fish early life history dynamics are poorly described or understood in the eastern GOA. The GOA-IERP provides an opportunity to investigate and compare patterns in the east with those in the west during two years with distinct oceanographic conditions. The coast of southeastern Alaska is a transitional zoogeographic region with characteristics similar to both the Aleutian and Oregonian regions, whereas the western GOA is within the Aleutian zoogeographic region. Preliminary results presented here describe seasonal, regional (eastern vs. western GOA), and interannual variation in occurrence and distribution of the broader ichthyoplankton assemblages. Species diversity in spring varied between regions and years: Simpson's diversity index (D) shows greater diversity in the western GOA in 2011, whereas diversity in the eastern GOA was greater in 2013. Spatial patterns of diversity were more consistent in the western GOA, with greater spatial variability in diversity in the eastern GOA. These patterns provide insight into the links between early life history stages and how environmental forcing may influence marine fish recruitment in the GOA.

Zooplankton Assemblages in lower Cook Inlet and Kachemak Bay 2012-2014

Robert Campbell, Caitlin McKinstry, Angela Doroff

Presenter: Angela Doroff

Email: adoroff@uaa.alaska.edu

We are exploring the physical environmental drivers associated with nearshore ecosystem through systematic hydrographic surveys in lower Cook Inlet and Kachemak Bay during 2012-2015. Concurrent with the hydrographic surveys, we collect zooplankton samples quarterly in lower Cook Inlet and outer Kachemak Bay and monthly in Kachemak Bay at three locations for each survey transect (current sample sizes are n = 55, n = 64, n = 93 for sample years 2012, 2013, & 2014, respectively). We collected zooplankton with a 60 cm diameter bongo-style net (333 micron mesh size) deployed to 50 m at each sampling location and conducted a vertical tow at 0.5 m/sec. Samples were preserved with 3% buffered formalin in the field and analyzed to lowest possible taxon at the Prince William Sound Science Center. Preliminary analyses suggest that monthly sampling is advantageous interpreting seasonal/annual patterns. *Pseudocalanus sp.* was present during all three sampling years across all stations and was most abundant in 2014 (across all years ~ $10^{1.7}$ ind m^{-3}) whereas *Calanus marshallae* was present in much lower densities all sampling years (across all years ~$10^{0.5}$ ind m^{-3}) and most consistently so for the monthly sampling locations. Crab zoea were present in all sampling years but most abundant in outer Kachemak Bay (across all years ~$10^{0.5}$ ind m^{-3}) and in the upper part of lower Cook Inlet during 2013. In our samples, there were 23 major taxonomic groups from 12 different phyla for which we did a cluster analyses to examine species grouping and an indicator species analyses to identify taxa characteristic to each of the clusters identified. We present the preliminary results of these analyses.

Effects of Stratification and Nutrient Limitation on Phytoplankton Blooms in Kachemak Bay, Alaska

Dominic Hondolero, Steve Kibler, Mark Vandersea, Wayne Litaker, Kristine Holderied

Presenter: Dominic Hondolero

Email: Dominic.Hondolero@noaa.gov

In Alaska, harmful algal blooms (HABs) are a threat to human health, mariculture operations, and may be linked to seabird and mammal mortalities. The 2014-2015 warm anomaly and coincident bloom of *Pseudo-nitzschia* in the northeastern Pacific caused fishery closures as well as seabird and mammal mortalities from California to Alaska. The effects of the Pacific warm anomaly on these species in the Gulf of Alaska show the need for understanding the environmental drivers affecting lower trophic levels, particularly the phytoplankton communities as they are suspected to have played a role in the mortality events during the summer of 2015. At NOAA's Kasitsna Bay Laboratory, partnered with researchers from the Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina, we have been conducting year-round monitoring of phytoplankton and oceanography in Kachemak Bay to assess seasonal and spatial phytoplankton distributions and triggers for HABs. Our monitoring efforts in Kachemak Bay have indicated that dissolved nutrient availability and water column stratification are important factors governing bloom development and termination as well as phytoplankton community structure. An intensive study conducted during the summer of 2015 investigated linkages between water column stratification and phytoplankton distribution. Where stratification was weaker, the Chlorophyll-A concentrations, in general, were higher. These results suggest that mixing from deeper, colder waters in plays a significant role in the timing and strength of HABs in Kachemak Bay. In addition to this study our regular phytoplankton monitoring program found several differences between the timing of this summer's blooms when compared to previous years and we also noted the presence of some species that had not been observed in Kachemak Bay during our previous monitoring, including some species that are typically found in warmer waters further south. Future work will further examine the role of water stratification and nutrients for HABs with the goal of creating a web-based HAB risk assessment tool that will be available to managers and resource users in Kachemak Bay.

WAVE 2

Tuesday, January 26
7:15 pm – 8:00 pm

Using Cell-Cycle Analysis to Measure Growth of Walleye Pollock *Gadus chalcogrammus* Larvae

Steven Porter

Presenter: Steven Porter

Email: steve.porter@noaa.gov

Growth rate is an important factor determining the survival of fish larvae because mortality rate decreases with size. Otolith daily increment counts are often used to measure the growth of fish larvae, but increment compression due to slow growth can make analyzing these otoliths difficult. Preliminary results of using cell-cycle analysis of muscle cell nuclei with flow cytometry as an alternative method for measuring the growth rate of Walleye Pollock *Gadus chalcogrammus* larvae are presented here. This method is based on the premise that cell proliferation is related to growth. An advantage of using flow cytometry is that it is faster than counting otolith daily increments, particularly when increments are difficult to discern due to slow growth. Walleye Pollock larvae were reared in the laboratory at 6°C for one month using a high prey ration diet, a low prey ration, and an unfed treatment. A generalized additive model (GAM) to estimate growth rate (mm/d) was formulated beginning at first feeding. Covariates tested were standard length (SL), body depth at anus, proportion of cells in the S phase of the cell cycle, proportion of cells in the G2 and mitosis (G2/M) phases, and the ratio of the number of S phase nuclei to the number G1 phase nuclei with high RNA content. The best fit model had SL, proportion of cells in the S phase, and proportion of cells in the G2/M phases for covariates, and R^2 = 0.84. Model estimated growth was more accurate for larvae > 7.5 mm SL (5% mean error), than for smaller larvae where accuracy was much more variable and in some cases error was > 100%. Larvae reared at 1.5° and 3°C will be included in a future model to cover a range of temperatures that typically occur in the Bering Sea and Gulf of Alaska. Accurate growth measurements of Walleye Pollock larvae will lead to better understanding of the relationship between environmental variability and larval survival in Alaskan waters.

Attention all Fish Squeezers! A New Compact and Waterproof Fish ID Book: A Handy Field Guide to the Nearshore Marine Fishes of Alaska

Scott Johnson, Darcie Neff, Mandy Lindeberg

Presenter: Mandy Lindeberg

Email: mandy.lindeberg@noaa.gov

We compiled this photo-rich guide as a tool to help all user groups identify nearshore marine fishes of Alaska without going through extensive taxonomic keys in the field. This guide culminated from 17 years (1998-2014) of research on the importance of the nearshore marine environment to fishery resources in Alaska. Our sampling efforts took us throughout the state of Alaska where we captured almost 750,000 fish in 1,142 beach seine hauls. Over the years we have taken thousands of photos of all species and life stages represented in our catches. The guide includes key photos of life-history stages (larvae to adults) captured and other useful information (e.g., diagnostic characteristics, distribution, and habitat use) on 113 fish species. Our guide is not meant to replace the many excellent identification guides available to researchers, but is intended to supplement these other guides with a portable and waterproof photo catalog to aid in fish identification in the field. The photographic richness of our handy field guide, in combination with the online Nearshore Fish Atlas of Alaska, provide researchers, managers, and the public with a unique and comprehensive synopsis on the nearshore marine fishery resources of Alaska. If you're a fish biologist or an outdoor enthusiast in Alaska, you should download a copy of this handy field. Google it or search on the NOAA Fisheries Alaska Fisheries Science Center website. Free printed field guides are available upon request.

Inter-annual and Spatial Variation of Juvenile Salmon Growth in the SE Gulf of Alaska

Brian Beckman, Jamal Moss, Wess Strasburger

Presenter: Brian Beckman

Email: brian.beckman@noaa.gov

Growth in an important physiological process, necessary for normal development and maturation of animals. Measures of growth can be useful ecological markers; indicative of population health, ecosystem productivity and ecosystem boundaries. Insulin-like growth factor 1 (IGF1) is a hormone that circulates in the blood and causes cells to divide and grow. A positive and significant correlation has been found between IGF1 and growth of juvenile salmon in controlled laboratory experiments. A juvenile fish survey has been conducted in mid-summer, in the SE Gulf of Alaska since 2010. IGF1 has been measured in juvenile pink, chum, sockeye, coho and Chinook salmon from this survey in 2010, 2012 and 2014. A general pattern of inter-annual variation was found across species, with IGF1 levels lowest in 2010 and highest in 2014. Coho and Chinook salmon IGF1 levels increased significantly between 2010 and 2012 and then again between 2012 and 2014. Sockeye and chum salmon IGF1 levels showed a similar pattern, with a lessor magnitude of change between years. In contrast, there was little difference in pink salmon IGF1 levels across years. Finally, a common intra-annual spatial pattern was found, with lower IGF1 levels found in fish collected closest to shore. Together these data suggest variation in the prey field of juvenile salmon temporally and spatially, and suggest differences between juvenile salmon feeding at different trophic levels (coho and Chinook vs pink salmon).

Seasonal Habitat Use and Reproductive Productivity of Northern Rockfish, *Sebastes polyspinis*, and Dusky Rockfish, *S. variabilis*, in Three Different Habitat Types in the Gulf of Alaska

Christina Conrath, Chris Rooper, Brian Knoth

Presenter: Christina Conrath

Email: Christina.Conrath@noaa.gov

The 1996 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act mandates the identification of Essential Fish Habitat (EFH) for each life stage of federally managed fish species. Our understanding of EFH for many rockfish species in the Gulf of Alaska (GOA) is rudimentary, especially their seasonal habitat requirements and the relative importance of specific habitat types. It is generally accepted that rockfish in the GOA have patchy distributions and frequently occur in rocky, hard, or high relief substrate. Many commercially important rockfish species are also associated with coral and sponge habitats in Alaska waters. The added complexity provided by coral and sponge habitats may offer juvenile and adult rockfish increased protection from predators and/or enhanced food resources similar to other structurally complex habitats. We are conducting a project examining the seasonality of rockfish distribution, abundance, and productivity across three habitat types: low relief, high relief rocky/boulder, and high relief coral/sponge. We examined the reproductive potential of adult northern, *Sebastes polyspinis*, and dusky rockfish, *S. variabilis* found within these habitats at two sampling sites in the Gulf of Alaska, in relationship to general indices of condition, food availability, and reproductive year. Reproductive potential was examined by calculating gonadosomatic indices and assessing development state, reproductive success, and fecundity. This research will enable us to better understand the relative importance of particular habitats to rockfish productivity throughout the year and provide data critical for understanding EFH for these species.

Comparison of Central and Eastern Gulf of Alaska Study Sites

Mark Zimmermann

Presenter: Mark Zimmermann

Email: mark.zimmermann@noaa.gov

In this analysis, five eastern Gulf of Alaska (eGOA) inshore study sites from the North Pacific Research Board's (NPRB) Gulf of Alaska - Integrated Ecosystem Research Program (GOA-IERP: http://www.nprb.org/gulf-of-alaska-project) Mid-Trophic Level (MTL) group were analyzed using numerous GIS (Geographic Information System) physical measurements such as water volume, surface area, and shoreline length. These eGOA sites include three small bays (Torch Bay, Graves Harbor, Islas Bay), a large semi-protected body of water (Salisbury Sound), and a large bay (Whale Bay). The metrics repeat those of a previously published analysis for five central Gulf of Alaska (cGOA) sites, which also included three small bays, an unprotected body of water, and a large bay. The intent of describing these inshore MTL study sites in terms of GIS metrics is to provide a basis for explaining differences in growth, abundance and survival of forage fish and juveniles of commercially important fish as determined by MTL field and laboratory work. First the three small eGOA sites were compared to each other, and then the two large eGOA sites were compared to each other, on the basis of the bay metrics, just like for the cGOA analysis. Finally all ten cGOA and eGOA sites were compared in multivariate analyses to determine if they were organized on a regional basis (central versus east), a size basis (small versus large), or some factor of previously unknown importance. The analyses generally agreed that location and size were both important grouping factors, with the cGOA small bays forming a group and the eGOA small bays forming a group, while the cGOA non-bay and large bay sites were the most distinct locations (outliers).

Energetic Content of Commercially Important Rockfish Species in Various Habitats

Tayler Jarvis, Christina Conrath, Brian Knoth, Ron Heintz

Presenter: Tayler Jarvis

Email: tayler.jarvis@noaa.gov

The specific habitat needs of the many rockfish species in the Gulf of Alaska (GOA) remains poorly understood. Rockfish species in the GOA tend to have distributions that occur in rocky or high relief substrates. Many of the commercially important rockfish in the GOA are also associated with coral and sponge habitats. Because of the complexity of coral and sponge habitats, benefits may be offered to juvenile and adult rockfish such as enhanced food resources and/or increased protection from predators. Research cruises were conducted during the spring, summer, and winter at two study sites in the central GOA and were focused on three commercially important rockfish species (Pacific ocean perch (*Sebastes alutus*), northern rockfish (*S. polyspinis*), and dusky rockfish (*S. variabilis*)). One objective of this project was to compare rockfish energy content across three habitat types: low relief, high relief rocky/boulder, and high relief coral/sponge. In addition, energy content of the livers and gonads of adult northern and dusky rockfish (males and females) was measured to determine how energy was being partitioned in the fish during the winter months. Preliminary results reveal differences in energy content among species across the three habitats in winter. In the low relief habitat, energy content was highest for both northern and dusky rockfish, while in the high relief coral habitat, the energy content of the same species was lowest. Energy content of the three species in the high relief rocky/boulder and high relief coral/sponge habitats was similar, with the northern rockfish having the higher energy content of the three species in both habitats. Female *Sebastes* sp. partitioned an average of 8.13% and 2.95% of their whole energy content to the gonads and livers, respectively, while only 0.33% and 1.89% was partitioned to the gonads and livers in males. This research, in conjunction with other aspects of this project, will enable us to better understand the importance of these habitats to commercially important rockfish species.

Influence of Scale-dependent Processes on Capelin (*Mallotus villosus*) Distributions in the Gulf of Alaska

David McGowan, John Horne

Presenter: David McGowan

Email: mcgowand@uw.edu

As part of the Gulf of Alaska (GOA) Integrated Ecosystem Research Program (GOAIERP), scale-dependent relationships of capelin (*Mallotus villosus*) densities were quantified as a function of oceanographic gradients, zooplankton prey fields, predators, and a potential competitor (age-0 walleye pollock, *Gadus chalcogrammus*). Within GOA food webs, capelin occupy an intermediate trophic position as planktivores where they function as both predator and prey; facilitating energy transfer from secondary producers to higher trophic level piscivores. Variability in the distribution of capelin in the GOA has previously been attributed to physical and biological processes that operate across a range of spatial and temporal scales. Capelin distributions were quantified during an acoustic-trawl survey conducted in the summer and fall of 2011 and 2013. Densities were significantly higher in 2013 and primarily concentrated along the edges of shallow submarine banks over the continental shelf east of Kodiak in both years. Wavelet analysis was used to identify scales that maximize variability in capelin distributions. Wavelets decompose a data series in the frequency domain to identify periods that account for variance in the series while retaining nonstationary features that may be biologically meaningful. Variance peaks in capelin densities were identified along most transects at fine- (0.44 to 0.72 km) and coarse- (32.6 to 52.9 km) scales, likely corresponding to aggregation size and the width of banks. Linear and nonlinear models were used to identify factors and interactions that influence capelin distributions at the scale of a predator-prey interaction and at coarser environmental scales. Cross-wavelets measured coherence between capelin and individual factors across a range of scales. Preliminary results indicate that capelin distributions may be influenced by intrusions of cold, nutrient-rich water from the GOA basin on to the shelf.

Prince William Sound Herring Research and Monitoring

Scott Pegau

Presenter: Scott Pegau

Email: wspegau@pwssc.org

This presentation provides an update on the Exxon Valdez Oil Spill Trustee Council (EVOSTC) sponsored herring research program in Prince William Sound. The Herring Research and Monitoring (HRM) program involves a series of monitoring projects combined with process studies to improve our understanding of Pacific herring in Prince William Sound. This presentation highlights some of the lessons learned over the past seven years.

Adaptive Energy Allocation Strategies of Age 0+ and 1+ Rockfish (*Sebastes* spp.), Pacific Cod (*Gadus macrocephalus*), and Walleye Pollock (*Gadus chalcogrammus*)

Ashwin Sreenivasan, Ron Heintz

Presenter: Ashwin Sreenivasan

Email: asreenivasan@alaska.edu

Rockfish (*Sebastes spp.*), Pacific cod (*Gadus macrocephalus*), and walleye pollock (*Gadus chalcogrammus*) represent a large proportion of fishable biomass in the Gulf of Alaska (GOA). As part of the Gulf of Alaska Integrated Ecosystem Research Project (GOAIERP), we conducted temperature and ration-dependent growth studies on juveniles of these species. Sustainable management requires understanding how juvenile fish respond to changing environments; defining optimal habitat in terms of energy allocation (somatic growth vs lipid storage) can help predict how these fish react to changing environments. Since life-history pressures can vary among age-classes, adaptive energy allocations maximize growth/condition in different habitats, giving an insight into age-class specific constraints on survival. A multispecies and multiage comparison indicated that rockfish and pollock represent extremes of energy allocation strategies, while cod appear intermediate. Age 0+ rockfish had higher growth sensitivity to temperature, and at 12 °C and unlimited rations had higher somatic growth and total-body lipid (~9%) than 1+ fish (~6.5%), indicating that 0+ fish allocate energy simultaneously towards growth and energy storage. This suggests that 0+ rockfish are susceptible to top-down and bottom up constraints, limiting them to a narrow warm pelagic habitat range that addresses both constraints, unlike 1+ fish that settle out to deeper thermally stable habitats. Age 0+ pollock conversely maximized growth in fall while 1+ fish maximized lipid storage.0+ fish also resumed growth earlier than 1+ fish in the spring, suggesting that 0+ fish have increased susceptibility to predation relative to starvation than 1+ fish. Age 0+ cod had both higher estimated optimum temperature for growth and growth sensitivity to temperature suggesting higher susceptibility to predation. Age 1+ cod were intermediate in having a seasonally adaptive allocation strategy, with heightened growth at warmer temperature, and heightened lipid storage at colder temperature (~2.7% at 4 °C vs ~2% at 12 °C). Optimum habitat criteria are thus ontogenetically driven. Age-specific adaptive energy allocation strategies are a tool that can be utilized to define changing essential fish habitats vital for survival and management of a given age-class.

Preliminary Observations of the Impact of Anomalous Ocean Temperatures on the Summer Distribution of Marine Fish in the Gulf of Alaska

Jennifer Boldt, Nicholas Bond, Edward Cokelet, Lawrence Hufnagle, Aimee Keller, Jacqueline King, Wayne Palsson, Dale Sweetnam, Phyllis Stabeno, Patrick Ressler, Anne Hollowed

Presenter: Anne Hollowed

Email: Anne.Hollowed@noaa.gov

In the fall of 2014, researchers projected a continuation of anomalously warm ocean conditions in the northeast Pacific Ocean using a new seasonal forecasting capability. Based on the results of these forecasts, the North Pacific Research Board funded a coordinated research project to examine the impacts of the unusual warming event in the northeast Pacific. This project will evaluate a unique dataset of acoustic and bottom trawl survey data that spans from the southern California Bight to the western Gulf of Alaska. An interdisciplinary multi-national research team has been assembled to conduct this research. The NPRB provided funds to supplement existing surveys with additional oceanographic measurements to enhance our ability to describe the mechanisms underlying observed shifts in spatial distributions. This paper will present the initial observations from the 2015 acoustic and bottom trawl surveys in the Gulf of Alaska and contrast them with previous years when NMFS conducted comprehensive surveys simultaneously in both the GOA and CCS (2003, 2005, 2011 and 2013). Preliminary results suggest that the sea surface temperatures in late July along the northeast Pacific were among the warmest on record and similar to 2005. The heat content was significantly warmer. Distributional responses of Pacific hake, walleye pollock, selected flatfish and rockfish to the observed warming will be presented by length category.

Habitat Suitability Models for Groundfish in the Gulf of Alaska

Jodi Pirtle, S. Kalei Shotwell, Mark Zimmermann, Jane Reid, Nadine Golden

Presenter: Jodi Pirtle

Email: jodi.pirtle@noaa.gov

Habitat-based predictors that may be useful to inform fish population estimates include habitat suitability by life history stage and the influence of encountering suitable habitat on survival. The Gulf of Alaska (GOA) Integrated Ecosystem Research Program seeks to identify and quantify the ecological regulators that influence recruitment strength for five federally managed groundfish species with high commercial and ecological value, Pacific cod (Gadus macrocephalus), walleye pollock (Gadus chalcogrammus), arrowtooth flounder (Atheresthes stomias), Pacific ocean perch (Sebastes alutus), and sablefish (Anoplopoma fimbria). As a key element of this process, benthic habitat suitability models (HSM) and maps were developed to generate a habitat metric for settlement stage juveniles to inform survival to recruitment for these species. To that end, a literature review was completed for each species to identify habitat requirements that could be modeled using spatial data. Gridded bathymetry and sediment surfaces were produced from datasets that were developed for this research program. Multi-scale terrain analysis was performed on these surfaces to develop a suite of benthic predictor variables to evaluate habitat suitability in the models. Given the paucity of observations for these early life stages, presence-only HSMs were developed for each species. GOA-wide maps were produced from the model results that describe available suitable habitat. For example, the HSM for settlement stage sablefish described suitable habitat as bathymetric low-lying areas with less rocky structure within 25-300 m depth. In comparison, the HSM for Pacific ocean perch described suitable habitat as bathymetric rises with rocky structure present on north-south facing slopes within 85-270 m depth. In the future, the settlement stage habitat suitability maps will be incorporated into the ecosystem considerations sections within the stock assessment reports for these species. This information may also be used to inform recruitment indices within the population models and to refine stage-specific definitions of Essential Fish Habitat.

The Highs and Lows of Herring: Characteristics of Collapse and Recovery

John T. Trochta, Trevora A. Branch

Presenter: John T. Trochta

Email: johnt23@uw.edu

Predicting when a collapsed fish population recovers is a highly desired, yet elusive objective for fisheries management. Challenges arise from the inability to predict or understand factors controlling the dynamics, and recovery potential, of collapsed fish populations including Prince William Sound herring. However, recorded instances of population collapse and recovery are frequent among herring populations, offering potential insight to the prospect of recovery as a shared phenomenon. I collected time series of herring populations from stock assessments, surveys, and catches to address this issue. From these I performed a meta-analysis to estimate time-to-recovery and determine the significance of factors that may control for this variable among herring. Preliminary results suggest that collapses on average last for 5 years before recovery occurs, and thus the Prince William Sound herring collapse is unusually long compared to other herring populations.

Salmon Blitz: Engaging Citizen Scientists in Documenting Salmon Habitat in the Copper River Watershed

Kate Morse, Kirsti Jurica

Presenter: Kate Morse

Email: kate@copperriver.org

An understanding of Pacific salmon habitat use at all life stages is necessary to protect and sustain Alaska's wild salmon populations into the future. Alaska Department of Fish & Game's (ADF&G) *Anadromous Waters Catalog (AWC)* is used to document all known rearing and spawning habitat of anadromous fish. However, due to the vast number of streams in Alaska and limited resources, not all salmon streams are currently listed or have detailed information about their use (e.g., rearing and/or spawning). The Copper River Watershed Project has worked with ADF&G and other partners throughout the watershed to develop and implement Salmon Blitz, a citizen science program designed to engage community volunteers in field surveys to collect data needed to nominate additional habitats to the AWC, and provide more spatial and temporal detail for habitats currently listed in the catalog. This project provides important data to inform management of salmon as well as hands-on learning opportunities for participants. By connecting people with their surroundings and deepening their understanding of the resources on which they depend, we hope to instill a greater sense of engagement and responsibility for the long-term health of the region's salmon. Over the course of three field seasons, over 300 volunteers helped assess a total of 50 sites, resulting in 32 nominations. As of 2014, nominations included 19.8 new stream kilometers, and 3.6 kilometers of upstream extent added to cataloged streams. New species were nominated for 12.8 kilometers of cataloged streams and life stage designation was added for 19.8 kilometers of cataloged streams.

Linking Juvenile Herring Winter Survival to Condition, Temperature, and Diet in Prince William Sound

Fletcher Sewall, Ron Heintz, Johanna Vollenweider

Presenter: Fletcher Sewall

Email: fletcher.sewall@noaa.gov

Year-class strength of Pacific herring (*Clupea pallasii*) may be largely determined by variable winter survival of young-of-the-year (YOY). To survive winter food scarcity, temperate fishes generally must metabolize their stored lipids for energy. Whether lipid stores are sufficient for survival is influenced by environmental conditions, including water temperature and prey availability. Winter starvation and predation risks for temperate fish are often highest for small individuals, making winter mortality size-dependent. Variation in size, water temperature, and diet are thus expected to strongly influence winter survival of herring.

For this study, a component of the Prince William Sound (PWS) Herring Research and Monitoring program, we investigated trends in YOY herring condition (% lipid), a growth index (RNA/DNA ratio), and diet (stomach contents) in November and March collections in 2009 through 2015. Herring size dictated their energy allocation strategy prior to winter, with individuals below a critical size of 70 – 80 mm length continuing to favor growth and larger individuals switching to lipid storage. High lipid stores enabled herring to minimize predation risk associated with winter foraging, as indicated by greater stomach fullness in herring with lipid content below 2% by March. Small herring were thus scarce by March due to a combination of growth and size-dependent winter mortality. Size-adjusted lipid content and RNA/DNA of YOY herring differed yearly, potentially due to annual temperature differences. Cold temperatures in 2012 likely promoted the observed high lipid levels through metabolic effects. High RNA/DNA in 2012 may reflect lower metabolic efficiency at lower temperature, which could result in growth comparable to warmer years with lower RNA/DNA. Temperature may modulate diet effects on herring condition: diet quantity and quality (energy density) were highest in 2011, yet fish condition was below average; meanwhile, diet quantity and quality in 2012 were low to average when fish condition was highest. These 2012 YOY herring would be expected to have high winter survival and contribute strongly to the 2015 adult spawning stock at age 3, but low numbers of spawners observed in 2015 made the stock age composition unclear. Further stock observations are needed to ascertain the 2012 year-class strength.

Investigating Multiple Causes of Historical Klawock Lake Sockeye Salmon Declines

Christine Woll, Aaron Prussian, Mary Richards, Michael Kampnich, Cathy Needham

Presenter: Christine Woll

Email: cwoll@tnc.org

Sockeye salmon from Klawock Lake have been important to people on Prince of Wales Island for thousands of years. Although the abundance of Klawock sockeye salmon has not been consistently monitored over this time period, it is evident that abundance over the last two decades is significantly less than historical values, and this has been a concern of local residents for some time. Because of these declines, there have been many previous efforts to address declines through research and management. We completed a retrospective analysis of this system to serve as a single source of information regarding the many research, management, and watershed restoration projects that concern Klawock Lake sockeye salmon and to present all of the relevant data and conclusions about Klawock Lake sockeye and the factors that may influence their productivity. Review of this previous research reveals that multiple factors likely conspire to influence the sockeye decline, and that while various research efforts have been completed over the years, significant gaps still exist. These factors include climatic influences on sockeye salmon in both the freshwater and marine environment, which are likely complex and difficult to predict; historical timber harvest, which altered the majority of available spawning habitats above the lake; predation impacts from both hatchery-reared coho salmon and other natural predators, as well as historical and current harvest of the stock. In addition to looking at historical datasets of this system, we began introductory data collection efforts to further assess the habitat condition for sockeye spawning on the lake. Field and imagery analysis-based assessments of spawning distribution and past and present river habitat suggest that habitat condition in areas likely to be historically productive have declined. Both the retrospective analysis and ongoing field work suggest potential options for both short and long-term research activities and management actions to address remaining data gaps and potential sources of decline. To be effective, both research and management activities will require a collaborative approach between multiple stakeholders to ensure lasting results in this important and complex system.

Ontogenetic Shifts in Energetic Condition of Pacific Ocean Perch Prior to Migration from Epipelagic to Demersal Habitat in the Gulf of Alaska

Wyatt Rhea-Fournier, Ron Heintz

Presenter: Wyatt Rhea-Fournier

Email: wyatt.fournier@noaa.gov

One of the goals of the Gulf of Alaska Integrated Ecosystem Research Program was to describe the early life history of Pacific ocean perch (POP) (*Sebastes alutus*). POP are live-bearers and larvae are extruded in deep waters along the continental shelf break in spring. Larvae take up an epipelagic existence and sometime after metamorphosis settle out of the water column. We examined changes in the size, energy content, and growth of post-metamorphic juveniles prior to settlement. We fit piecewise linear regressions and generalized additive models (GAMS) to these data to detect ontogenetic shifts in growth and energy allocation. Results indicate that for three condition indices there is an inflection point between 25 and 30mm where energy density and lipid allocation increase and RNA/DNA (protein synthesis) decrease. A secondary goal of this study is to observe potential environmental influences on condition by generating a series of GAMs using the residuals from the length and condition relationships with epipelagic habitat attributes. Preliminary results suggest that condition residuals have a non-linear relationship with sea surface temperature with the highest condition occurring in offshore regions where temperatures were between 12 and 13 degrees Celsius. The decrease in condition for temperatures higher than 13 degrees is alarming considering the recent warming of the GOA after the "Warm Blob" phenomenon that brought sea surface temperatures above 15 degrees. Young of the year POP face the challenge of surviving in the epipelagic environment while maximizing growth and energy storage to prepare for the winter migration to new habitat. This challenge may become more difficult considering the current climatic trends in the Gulf of Alaska.

Fatty Acid Composition of Fasting Herring in Prince William Sound

Ron Heintz, Lawrence Schaufler, Fletcher Sewall

Presenter: Ron Heintz

Email: ron.heintz@noaa.gov

We tested the hypothesis that the fatty acid compositions of the herring could be used as natural tags to determine if age-0 herring move between bays during the winter in Prince William Sound (PWS). Understanding the movements of age-0 herring is important to identifying the appropriate spatial scale for sampling under the Exxon Valdez Oil Spill Trustee Council funded herring monitoring program. Our hypothesis was based on two assumptions: 1) fasting herring retain their fatty acid signatures over time, 2) the fatty acid compositions of herring in different bays differs at the onset of winter because each bay has a unique prey field. We conducted a laboratory study to test the first assumption and field data corroborated our second assumption that prey fields vary among bays. We examined our hypothesis by sampling fish in fall and spring from a variety of bays in PWS and comparing their fatty acid signatures across a range of spatial scales. The results of our laboratory study indicated that herring retain their fatty acid signatures over time. Our field studies demonstrated that herring fatty acids can be discriminated between the eastern and western Sound, but there was little difference between herring among bays in the western Sound. Nor were there differences between locations within a bay. Within bays there was evidence of a change in fatty acid signature over winter. However, not all fish altered their signatures over winter and the altered signatures were unlike any of the fall signatures. In addition, those individuals that had altered signatures also tended to have very low lipid levels. We concluded that fish with low lipid levels had commenced foraging and altered their fatty acid signatures. Our data demonstrate that there are distinct differences in the prey fields available to age-0 herring between eastern and western PWS and the populations in the western part of the Sound but higher levels of detail cannot be discriminated by fatty acids. Finally there was little evidence of movement of fish between the eastern and western portions of PWS.

Delayed Energy Allocation to Lipid Reserves until Maturation by Sablefish in the Gulf of Alaska

Wyatt Rhea-Fournier, Robert Bradshaw

Presenter: Wyatt Rhea-Fournier

Email: wyatt.fournier@noaa.gov

Alaskan sablefish are a highly valued commercial fish that are sought out by consumers worldwide for its flavorful flesh that can be attributed to a very high fat (lipid) content. Although adult, mature sablefish have always been recognized as having an elevated fat content relative to other commercial fish, it is not as well known that prior to maturation sablefish have a tremendously high growth rate that exceeds all other pelagic and groundfish species. The purpose of this study is to observe lipid content of Gulf of Alaska (GOA) sablefish throughout their early life history and maturation with the hypothesis that high growth rates prior to maturity is achieved by allocating energy to growth in size and not to energy reserves. Sablefish collected during the summer months in the Eastern GOA by surface trawl, longline, and jig were analyzed for lipid content at the Auke Bay Laboratories in Juneau, AK. Results indicate that during the first five years of life, sablefish maintain consistently low energy reserves in the form of lipids (<2%). As sablefish begin to mature during their sixth year, lipid reserves accelerate rapidly with both males and females allocating over 20% of their body mass to lipids. Relative to other groundfish in the Pacific Ocean, this strategy of delaying lipid allocation until maturation is unique and may be the reason that juvenile and immature sablefish are able to achieve such high growth rates and maximize their size at age.

Pacific Herring Genetics

Sharon Wildes, Jeff Guyon, Hanhvan Nguyen

Presenter: Sharon Wildes

Email: sharon.wildes@noaa.gov

Pacific herring (Clupea pallasi) are a critical component of the Prince William Sound ecosystem. This small forage fish is a key link between primary productivity and upper trophic levels of fish, birds, and mammals. Herring stocks have remained depressed for the majority of the last 20 years and the reasons for their lack of recovery are unknown. The purpose of our study is to examine the genetic stock structure of Pacific herring in Prince William Sound, and to provide information that may aide in best management practices for recovery of this critical species. Genetic information was collected at fifteen microsatellite markers from samples of herring collected from eastern Prince William Sound, northern Montague Island, and several locations outside and adjacent to the Sound, including Kayak Island. Analyses will survey the geographic structure and temporal stability of the genetic data. Additionally, data from the large eastern Prince William Sound collections will be partitioned by year class for finer-scale analyses.

Using Scales to Assess Age at First Spawn for Pacific Herring (*Clupea pallasii*)

Johanna Vollenweider, Ron Heintz, Jacek Maselko

Presenter: Johanna Vollenweider

Email: johanna.vollenweider@noaa.gov

The age at which fish mature affects the lifetime reproductive success of individuals. On a population level, age at maturation is therefore a key factor influencing stock productivity. Age-structured stock assessment (ASA) models often include age-at-maturity as an input parameter, which can have significant effects on estimates of fish abundance and consequently allowable catch. In Prince William Sound, Alaska, where Pacific herring (*Clupea pallasii*) have been in a depleted state of abundance since the early 1990's, age at maturity is assumed to be 3 in the ASA management model for lack of other knowledge, has been cited as an important data gap. We seek to validate a method commonly used for Norwegian spring-spawning herring (*Clupea harengus*) using scale growth measurements to determine age at first spawn in Pacific herring. For nearly a century, it has been understood that annual rings on herring scales are added relative to their body size and therefore the growth and age of individual fish. Spawning is an energetically expensive process that affects the growth rate of fish and a corresponding reduction in width of annual growth layers occurs on scales. Consequently, scale growth rings ought to reflect the spawning history of an individual herring over the course of their life time. This method for evaluating age at maturity is advantageous over evaluation of the age-structure of herring found in spawning schools because spawning migrations are energetically expensive and immature fish are not likely to be found there. We compared histological samples of Pacific herring gonads to scale growth increments to validate the Norwegian method of determining maturation age. Furthermore, we evaluated a scale growth increment dataset collected by the Alaska Department of Fish and Game using growth frequency distributions to look for indications of changing age at maturity. Age at maturity can vary depending on environmental conditions that influence fish growth and reproduction costs. Shifts in age at maturity in Prince William Sound herring could provide insight into the continued depressed population.

Whale SENSE Alaska: Setting a Higher Standard for Stewardship and Responsible Whale-Watching Practices

Aleria Jensen, Allison Rosner, Monica Pepe, Regina Asmutis-Silvia

Presenter: Aleria Jensen

Email: aleria.jensen@noaa.gov

The Whale SENSE stewardship program for whale watch operators was introduced to Alaska for the first time in 2015. The program, which began in 2009 along the U.S. East Coast, is a partnership between NOAA Fisheries Alaska Regional Office, Whale and Dolphin Conservation, and NOAA Fisheries Greater Atlantic Regional Office to empower whale watching industry leadership to serve as conservation stewards in the preservation of large whale species. Whale SENSE Alaska is a voluntary education and recognition program offered to Juneau area whale watch companies to set positive standards for responsible on-water practices, advertising, education and stewardship. Whale SENSE Alaska was implemented to respond to tremendous growth in the region's commercial whale watch industry over the past decade, to meet a demonstrated need for additional operational guidelines, communication and coordination on the water, and to work in tandem with NOAA Fisheries existing Alaska Humpback Whale Approach Regulations. The program was developed in close collaboration with Juneau area whale watching companies through a series of operator-agency meetings which took place throughout 2014-15. During this process, the program was refined and adapted to fit local industry needs and area geography, and to minimize potential harassment to humpback whales. Seven companies joined the program for its pilot season in Juneau. Members of the whalewatch industry will continue to play a significant role in the future development and advancement of this program.

Validation of Hair as a Novel Tissue for Assessing Adrenal Hormones in Young Steller Sea Lions (*Eumetopias jubatus*)

Mandy Keogh, Shawna Karpovich

Presenter: Mandy Keogh

Email: mandy.keogh@alaska.gov

Hair is increasingly being used to investigate the concentration of trace elements, heavy metals, stable isotopes, and steroid hormones in mammals. Hair is less invasive to collect from live subjects than many other tissues, not altered by capture and handling, suited to long-term storage and remote field collection, and can provide information on the health of individuals and populations. Steroid hormones including cortisol have been shown to accumulate in keratinized tissues such as hair and whisker (Macbeth et al., 2010; Karpovich et al., in prep). In the present study, hair (50-200 mg) was processed as described by Macbeth et al. (2010). Ground hair samples were stored in 1.5 ml plastic vials at room temperature in the dark until extraction of steroid hormones following the methods described by Macbeth et al. (2010) and Hunt et al. (2014). Briefly, 100% methanol was combined with powdered hair samples (25 mg), vortexed and then allowed to slowly spin on a rotator for 24 h at room temperature, following which the samples was centrifuged and snap frozen after which the supernatant was collected and frozen. A subsample of the methanol with extracted steroid hormones were dried under nitrogen gas and reconstituted in assay buffer. Pools of extracted hormones of male and female SSLs were made from multiple samples and used to validate commercially available cortisol and aldosterone enzyme immunoassay kits. Standard methods including recovery of added mass, parallelism and dilution linearity were used for the laboratory validations of ELISA kits for each adrenal hormone (Keogh et al., 2010; Hunt et al., 2014).

A Re-Examination of the Timing of Pupping for Steller Sea Lions (*Eumetopias jubatus*) Breeding on Two Islands in Alaska

Carey Kuhn, Kathryn Chumbley, Devin Johnson, Lowell Fritz

Presenter: Carey Kuhn

Email: Carey.Kuhn@noaa.gov

An understanding of population vital rates and estimates of survival are critical for assessing mechanisms of population change and for developing conservation and management priorities. For Steller sea lions, which are distributed from Japan to California, population demographics vary spatially, with some regions increasing while others are declining. To assess changes in population size, aerial surveys are conducted annually to quantify pup production. The timing of these surveys is critical for accurate population estimates and survey windows were established based on historical estimates of mean pupping date. Using data from long-term study sites, we reassessed mean pupping date for Steller sea lions at breeding islands in the central Gulf of Alaska (Marmot Island, MI) and the eastern Aleutian Islands (Ugamak Island, UI). Using land-based counts of pups during the breeding season (May-August), we quantified mean pupping date and the duration of the pupping season between 2003 and 2013 and compared these data to historical mean pupping dates at MI and UI between 1977 and 1999. Between 25 and 65 daily pup counts were analyzed for each year (mean: 49.6 ± 0.7 counts). The mean pupping date of 09 June (range: 07-13 June) on MI was not significantly different among years; however, pupping dates were different between breeding beaches on MI (3.4 days difference). On UI the mean pupping date of 08 June (range: 03-12 June) varied among years but not between breeding beaches. On UI, mean pupping date was earlier than previously reported by 2.8 days, but on MI mean pupping date was not different from historical dates if both breeding beaches were combined. On both islands, 95.0% ± 0.7% of the pups were born prior to the planned start of aerial surveys in Alaska (24 June; day 55). Our results demonstrate that although pupping date is variable and may have shifted compared to historical data at some sites, the current timing of the aerial survey is ideal for obtaining peak pup counts for Steller sea lions in these regions.

Method Development for Marine Mammal Primary Cell Lines

Katrina Counihan, Verena Gill, Caroline Goertz, Tuula Hollmen

Presenter: Katrina Counihan

Email: katrinac@alaskasealife.org

Marine mammals around Alaska are being impacted by climate change and anthropogenic activity. Novel pathogens can survive in the warming waters resulting from climate change and may increase mortality events. Additionally, oil and gas development, increased ship traffic, and melting sea-ice could expose them to higher levels of contaminants. New laboratory methods are needed to assess the effects of pollutants and pathogens on marine mammals. Primary cell lines are valuable laboratory tools that are cost-effective and can act as a surrogate for live animal studies. Sea otters are a keystone species in the marine environment and also act as indicators because they inhabit the nearshore environment, share human resources and are easier to observe and sample than other marine mammals. The Pacific walrus population is threatened by habitat loss due to melting sea ice and novel pathogens. Therefore, we established methods to develop primary cell lines from liver, aorta and intestine in sea otters and walruses. A hepatocyte extraction method was refined to reduce red blood cell contamination and extract cells from liver tissue. Two methods were used to extract endothelial cells from aorta, collagenase and collagenase/trypsin digestion. The collagenase/trypsin method yielded a higher cell count. Two methods were also used to extract epithelial cells from intestinal tissue, chelation and collagenase/dispase digestion. Both methods were successful, but the chelation method yielded a higher number of crypts. Heart and intestine from sea otters were used up to 72 hours post-mortem providing an increased opportunity to develop cell lines from stranded animals. Liver tissue was more sensitive to degradation and was most successfully extracted from juvenile animals 24 hours post-mortem. The availability of sea otter and walrus primary cell lines will allow a wide range of laboratory studies to be conducted regarding their health. The methods that were developed worked on two distinct species and, therefore, may be applicable to other marine mammals.

Growth, Abrasion, and Molt of Harbor Seal (*Phoca vitulina*) Whiskers

Shawna Karpovich, John Skinner, Lori Polasek, Carlene Miller, Mandy Keogh, Grey Pendleton

Presenter: Shawna Karpovich

Email: shawna.karpovich@alaska.gov

Keratin, a fibrous protein, is laid down in continuously growing tissues, such as whiskers. Stable isotopes, steroid hormones, and contaminants are found in keratin, and analysis of serial sections of whiskers can provide a long-term record of an animal's diet and health. Appropriate interpretation of the information stored in whisker keratin requires that the timing of whisker growth and molt be defined. Therefore, we conducted a fine scale examination of harbor seal (*Phoca vitulina*) whisker growth, abrasion, and molt. Harbor seal whiskers grew in a curvilinear fashion consistent with the Bertalanffy growth curve. Newly emerged whiskers grew rapidly at rates up to 1.7 ± 0.3 $mm \cdot d^{-1}$ and had slowed to 0.03 ± 0.01 $mm \cdot d^{-1}$ during the 60 days prior to molt. Whisker lengths varied significantly with follicle position, and the longest whiskers grew from the follicles in the most caudal positions on the whisker beds. Initial growth rates were similar between follicles, and the greater length of whiskers in the caudal positions was achieved by a slower decline in the initial growth rates. In other words, whiskers that ultimately grew to be longer grew fast for a longer duration. Abrasion from the whisker tip was 0.018 ± 0.048 $mm \cdot d^{-1}$ during the 60 days prior to molt, and assuming whisker abrasion is consistent across time would represent approximately 6.6 mm of loss during one year of growth. The timing of whisker molt varied between individual harbor seals. Whiskers molted annually and in a pattern that suggested whisker molt likely began at the caudal margin of the whisker bed and progressed toward the nose. Our results provide information about whisker growth and molt patterns that can facilitate the creation of a temporal record for interpretation of physiological parameters concerning diet and health of harbor seals.

Seasonal and Developmental Differences in Blubber Stores of Beluga Whales in Bristol Bay, Alaska using High Resolution Ultrasound

Leslie Cornick, Lori Quakenbush, Stephanie Norman, Coral Pasi, Pamela Maslyk, Kathy Burek, Caroline Goertz, Roderick Hobbs

Presenter: Leslie Cornick

Email: lcornick@alaskapacific.edu

Diving mammals use blubber for a variety of structural and physiological functions, including buoyancy, streamlining, thermoregulation, and energy storage. Estimating blubber stores provides proxies for body condition, nutritional status, and health. Blubber stores may vary topographically within individuals, across seasons, and with age, sex and reproductive status; therefore, a single full-depth blubber biopsy does not provide an accurate measure of blubber depth, and additional biopsies are limited because they result in open wounds. We examined high-resolution ultrasound as a non-invasive method for assessing blubber stores by sampling blubber depth at 11 locations on beluga whales in Alaska. Blubber mass was estimated as a proportion of body mass (40% from the literature) and compared to a function of volume calculated using ultrasound blubber depth measurements in a truncated cone. Blubber volume was converted to total and mass-specific blubber mass estimates based on the density of beluga blubber. There was no significant difference in mean total blubber mass between the two estimates (R^2=.88); however, body mass alone predicted only 68% of the variation in mass-specific blubber stores in juveniles, 7% for adults in the fall, and 33% for adults in the spring. Mass-specific blubber stores calculated from ultrasound measurements were highly variable. Adults had significantly greater blubber stores in the fall (0.48 +/- 0.02 kg/kg_{MB}) than in the spring (0.33 +/- 0.02 kg/kg_{MB}). There was no seasonal effect in juveniles. High-resolution ultrasound is a more powerful, non-invasive method for assessing blubber stores in wild belugas, allowing for precise measurements at multiple locations.

Detection of Pregnancy and Stress Biomarkers in Large Whales

Shannon Aktinson, Janice Strayley, Adam Pack, Chris Gabriele, John Moran, Diane Gendron, Kendall Mashburn

Presenter: Shannon Aktinson

Email: skatkinson@alaska.edu

The lack of data and information on the reproductive biology of large whales reduces the ability to effectively manage for the recovery of large whale species. Corticosteroids are essential to an animal's ability to adapt to fluctuations in environmental and physiological demands. Progesterone can be used as a primary index of reproductive activity and together with corticosteroids functions to produce a successful pregnancy. The goal of this study is to promote the use of endocrine techniques to advance our knowledge of cetacean physiology and their responses to change in the environment. Using blubber biopsies, both progesterone and cortisol were measured in female humpback (n=89) and blue whales (n=56). Both humpback and blue whales had no significant differences in progesterone concentrations from calves and lactating females. A method was determined from these data to ascertain non-pregnant versus pregnant whales. The pregnant females had significantly higher progesterone concentrations than all other groups of female whales. Cortisol concentrations were significantly higher in male blue whales than female whales on calving grounds. Our data biologically validate the use of these steroid hormones to assist in gaining a better understanding of reproductive and metabolic physiology in large whales.

Endocrinology Profiles for Assessing the Status of Blue Whale (*Balenoptera musculus*) Population from the North Pacific Ocean

Valentina Melica, Shannon Atkinson

Presenter: Valentina Melica

Email: vmelica@alaska.edu

Blue whales (*Balenoptera musculus)* are categorized as one of most endangered species among mysticetes, with very low evidence of population size increase since the early 1990s. This species occurs worldwide and is separated into unique populations by ocean basins (i.e., North Atlantic, North Pacific and Southern Oceans). The North Pacific population ranges from the Gulf of California, a potential breeding ground, up to the Aleutians and Gulf of Alaska, but has been severely exploited by hunting in the 1900s, and is estimated to currently consist of 2500 individuals. Photo-identification is an important tool used to estimate population abundance and movement, however, very little is known about other main characteristics associated with population dynamics. Reproduction physiology and stress responses to anthropogenic insults are key to understanding growth rates, fecundities and reproduction cycles. Thus, gaining a more comprehensive insight into reproductive physiology and offsprings development would contribute to the assessment of recovery trends.

A better evaluation of population growth can be achieved through the estimation of important biological parameters such as sexual maturity, survival rates and annual pregnancy rates. Stress responses to ship strikes and other anthropogenic encounters is one key component to understanding the health and survivorship of the species. Hormones such as corticosteroids are important biomarkers for physiological studies and are widely used in other marine mammalian species studies to monitor health and stress levels. The objective of this study is to quantify physiological changes occurring during the reproductive cycle and/or during a stress event in order to assess pregnancy status and estimate annual pregnancy rates. Concentrations of estrogen and corticoids in blubber will be measured through enzyme immunoassays validation. Endocrine profiles and long-term photo-identification database will be used to determine reproductive status and calculate pregnancy rates, and ship strike of sampled individuals with photo-identification history will allow stress response assessment. This study will provide key knowledge for better understanding the overall health and conservation status of the species.

Location, Location, Location: Is the Largest Harbor Seal Haulout in the World any Different from the Others?

John Jansen, Jay Ver Hoef, Gavin Brady, Peter Boveng

Presenter: John Jansen

Email: john.jansen@noaa.gov

Harbor seals (*Phoca vitulina*) are a wide-ranging pinniped, occupying diverse habitats across the majority of coastlines in the northern Pacific and Atlantic oceans. One of the most remote places they inhabit is the northeastern Gulf of Alaska, a 500-km stretch of exposed coastline with sparse human settlements and few embayments. One of these, Icy Bay (IB: ice field ~75 km^2), has tidewater glaciers that provide floating ice, supporting the largest aggregation of this species in the world (>10,000 seals). A nearby, much less abundant, glacial haul-out (Disenchantment Bay [DB: ~70 km^2]; 2,000 seals) allows for a comparison of life history traits of the two populations and their ice habitat, to help explain the difference in use. We hypothesize that better habitat quality at IB promotes higher pup survival and ultimately population size. Using aerial-vertical photographs from 49 surveys over two years at the two sites, we mapped and measured the lengths of ~30,000 seals, including ~10,000 pups, and characterized their ice habitat. We found peaks in ice coverage corresponding to the early pupping period (mid-May) followed by a seasonal decline; IB consistently had twice the ice coverage, and ice bergs used by seals were twice the size of those in DB. Growth rates of pups were similar, but pupping phenology was advanced by 7-13 days at IB. Larger mothers tended to pup earlier; those at IB left pups unattended (an indication of weaning) later compared to DB. Our findings suggest that IB supports more seals due to more reliable ice conditions for hauling out. Over time, this may have led to better condition and higher productivity of females, earlier breeding, longer lactation, and higher pup survival. Differential recruitment, immigration, and other effects stemming from disturbance could also favor IB, given that DB has ~100 annual cruise ship visits during pupping.

The Susitna River Delta as a Calving Ground: Evidence from Observation of a Cook Inlet Beluga Whale Birth and the 2005-2015 Seasonal and Geographic Patterns of Neonate Occurrence in Upper Cook Inlet

Tamara McGuire, Amber Stephens, Brad Goetz

Presenter: Amber Stephens

Email: astephens@lgl.com

The scientific literature has not yet identified if distinct calving grounds and calving seasons exist for endangered Cook Inlet Beluga whales (CIBW), as they do with other beluga populations. Specific calving grounds or seasonal calving periods for CIBW have not been designated because births in the wild have not been documented. Here we describe a CIBW birth that was observed and photographically documented on July 20, 2015 in the Susitna River Delta, Upper Cook Inlet Alaska. To our knowledge this is the first documentation of a CIBW birth. We also describe seasonal and geographic patterns of neonate (newborn) occurrence collected during 11 years of boat- and land-based photo-id surveys in Upper Cook Inlet, conducted during the April-November ice-free season. Neonates were seen over a 5-12 week period every field season, usually beginning mid-July. Exact timing of the first neonate of the season varied annually by a matter of a few weeks. In all instances, the first neonates of the field season were seen in the waters of the Susitna River Delta (defined as between the Beluga and Little Susitna Rivers), and as each field season progressed, neonates were seen in all other survey areas where belugas were encountered (Susitna River Delta, Knik Arm, Turnagain Arm, Chickaloon Bay, and the Kenai River). Keeping in mind the bounds of the study area and study period, these results provide evidence to support the designation of the Susitna River Delta as CIBW calving grounds, the nearshore areas of Upper Cook Inlet as nursery grounds, and mid-July through mid-October as the peak calving period in Upper Cook Inlet.

Alaska Marine Mammal Observer Program Summary for 2012-2013

Kristy Long, Bridget Mansfield

Presenter: Kristy Long

Email: kristy.long@noaa.gov

The Marine Mammal Protection Act mandates that NOAA's National Marine Fisheries Service (NOAA Fisheries) monitor incidental mortality and serious injury (bycatch) of marine mammals in commercial fisheries. For commercial fisheries managed by the State of Alaska, NOAA Fisheries created the Alaska Marine Mammal Observer Program in 1990. The Program objectives include recording data on bycatch of all species, obtaining reliable estimates of incidental bycatch of marine mammals, identifying changes in fishing methods or technology that may affect incidental bycatch, and collecting biological samples to support scientific research. During the 2012 and 2013 fishing seasons, the program observed a portion of the Southeast Alaska salmon drift gillnet fishery, specifically Alaska Department of Fish and Game Management Areas 6 (Prince of Wales), 8 (Stikine), and 7A (Anita Bay terminal harvest area). Vessels were randomly selected for observation, and observers monitored fishing operations from a separate vessel (i.e., alternate platform). The program achieved 6.4% and 6.6% observer coverage in 2012 and 2013, respectively. In total, 7 marine mammals and 105 seabirds were observed incidentally taken in the fishery across both seasons. The 7 marine mammals included 1 Dall's porpoise in 2012 as well as 4 harbor porpoise, 1 humpback whale, and 1 sea otter in 2013. NOAA Fisheries determined that the Dall's porpoise, 2 harbor porpoise, and the humpback whale were seriously injured; 2 other harbor porpoise were not seriously injured. The data were analyzed to produce bycatch estimates by Manley (2015). The data were stratified into sub-areas 6A, 6B, 7A, 8A and 8B. A post-stratified sampling design was used because the fishing vessels could fish in any sub-area (or even multiple sub-areas) on a given day. Fish landings data were used to represent effort (because other metrics of effort, such as the number of sets in each sub-area, were not available). Over the two years, the total resulting bycatch estimates were 18 Dall's porpoise, 23 harbor porpoise, and 11 humpback whales. NOAA Fisheries will consider these bycatch estimates in the context of stock assessments and evaluate whether current bycatch levels pose a significant risk to these marine mammal stocks.

Oil Spill Response: Mitigation Measures to Minimize Impacts to Marine Mammals

Sadie Wright, Lori Verbrugge

Presenter: Sadie Wright

Email: sadie.wright@noaa.gov

The National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (FWS) work with the U.S. Coast Guard (USCG) and other trustee agencies and stakeholders to plan and prepare for oil spill response. In Alaska, marine mammals are present along most of the state's 44,000 miles of coastline and offshore throughout the 200 nm Exclusive Economic Zone. In training and during real response incidents in or around Alaska's marine waters, NMFS and FWS provide the USCG with mitigation measures that, when implemented, will reduce impacts of the response on marine mammals. Mitigation measures that have been implemented recently in Alaska include no-entry zones for response vessels near Steller sea lion haulouts and rookeries, no-approach zones around whales, and reporting requirements. Additional mitigation measures that could be applied in larger spill scenarios include protected species observer requirements, speed limits/restrictions, rehabilitation of oiled or injured marine mammals, restrictions of in-situ burns upwind of marine mammal concentrations, deterrence, and distance restrictions. In addition, marine mammals and their habitat and prey will be considered in net environmental benefit analyses when determining whether to use various spill response tactics (e.g., dispersants, in-situ burns, and others).

Large Seasonal Aggregation of Steller and California Sea Lions Utilize Spawning Eulachon in the Eastern Gulf of Alaska

Lauri Jemison, Susan Oehlers, Nate Catterson

Presenter: Lauri Jemison

Email: lauri.jemison@alaska.gov

At the Alsek and Akwe Rivers in the eastern Gulf of Alaska, Steller sea lions (SSLs) congregate in large numbers during late winter and spring to feed on aggregating pre-spawn and spawning eulachon. Since 2000, the U.S. Forest Service (USFS) has conducted counts from fixed wing aircraft to estimate SSL numbers in this region. In 2012, the Alaska Department of Fish and Game began collaborating with the USFS to expand survey effort using a revised methodology and higher resolution cameras to photo-document SSLs branded for ongoing vital rates studies. We collected aerial images during ten surveys from 2012-2015; these images provided count data and allowed us to identify branded individuals. Nearly 5,000 sea lions were present at the Alsek and Akwe Rivers on April 11, 2014, the highest count during all survey years. We photo-confirmed between 43-114 unique SSL brands annually, representing pups born at 10 different rookeries in the Gulf of Alaska, Oregon, and California. Twelve to sixteen percent of branded animals were born in the western Distinct Population Segment, where they are listed as endangered. Unexpectedly, we also documented the presence of many California sea lions (CSLs) hauled out among the SSLs (>225 CSLs were present on one survey). A previous study that summed all observations of CSLs in Alaskan waters from 1973 through 2003 reported a total of 52 CSLs during those three decades combined. The presence of hundreds of CSLs in Alaska was previously unknown; continued monitoring is essential to understanding the importance of this region to foraging sea lions and to document possible shifts in sea lion distribution related to warming oceans and climate change.

Sea Otters versus Sea Stars as Major Clam Predators: Evidence from Foraging Pits and Shell Litter

Sarah Traiger, Brenda Konar, Angela Doroff, Lauren McCaslin

Presenter: Sarah Traiger

Email: sbtraiger@alaska.edu

Sea otters and sea stars both excavate bivalves in the nearshore environment and leave behind foraging pits. If the source of pits can be determined with confidence, then pits may provide information about benthic foragers without direct foraging observations. Our objectives were to determine if pits (using dimensions) or clam shell litter found in the field can be attributed to sea otters or sea stars and to determine how pit shape changes over time. Here, we hypothesize that recent (< two weeks old) pits can be distinguished based on measurable characteristics (major axis, minor axis, pit depth, and how sediment is piled) and that after two weeks, sea otter and sea star pits will still be distinguishable. Lastly, we hypothesize that shell litter can be used to assign clam predation. In Kachemak Bay, Alaska, we surveyed four sites every two weeks at 10 m and two sites at 0 m and documented forage pit characteristics from May to August in 2014. Each pit was marked to distinguish new pits from those previously surveyed. To determine if pits could be distinguished, we performed a cluster analysis on measured characteristics. To determine how pit dimensions change over time, experimental pits were dug at each site to match literature descriptions of sea otter and sea star pits and were measured for changes in dimensions two weeks later. Additionally, we collected shell litter at each site and determined the source of mortality. We measured 109 foraging pits across all sites but were unable to identify the source of the pits based on their measured characteristics. Additionally, experimental sea otter and sea star pits were not distinguishable from each other after two weeks. Based on shell litter, relative foraging rates could be determined and were found to be equal between sea otters and stars at all but one site, with only 2.4% of shells attributed to other predators. Our research demonstrates that in Kachemak Bay, sea otter and sea star foraging pits cannot reliably be distinguished in the field but that clam shell litter is useful for determining source of clam predation.

Stable Isotope Analysis of Humpback Whales (*Megaptera noveangliae*) to Confirm Diet during Winter Foraging

Kevin Boswell, Mark Barton, Alexandra Brownstein, Jan Straley, John Moran

Presenter: Alexandra Brownstein

Email: abrow183@fiu.edu

Humpback whales (*Megaptera novaeangliae*) in Prince William Sound (PWS), have been documented feeding primarily on Pacific herring (*Clupea pallasii*) in winter. These whales may be preventing the recovery of some local herring populations through top down control. Previous analysis of stable isotopes, from samples collected during the summer, confirmed that humpback whales in PWS are feeding at a significantly higher trophic level than humpbacks in the Gulf of Alaska. The higher trophic level is likely from feeding upon Pacific herring however, visual observations of target prey were not recorded. The goal of this analysis was to confirm that the whales' diet, documented visually during fall and winter, is reflected in the stable isotope analysis indicating feeding at higher trophic levels. Stable isotope analysis of carbon and nitrogen were used to determine the assimilated diet of humpback whales (N= 18) Prince William Sound, Alaska during 2014/15. Isotope analyses were conducted on humpback whale skin, as well as local forage species and basal resources to be used in Bayesian isotope mixing models to elucidate the trophic relationships between whales and their prey. Model results were compared to in situ feeding observations to determine the foraging reflected the visually observed diet of individual whales. Understanding the predation on forage species offers valuable insight about the impact of rapidly recovering whale population.

Steller Sea Lion Survivors: A Retrospective on the Impact of Alternative Research Methods on an Endangered Species

Courtney Shuert, Jo-Ann Mellish, Markus Horning

Presenter: Courtney Shuert

Email: cshuert@gmail.com

Two novel research approaches were developed to access to wild juvenile Steller sea lions under controlled conditions. The Transient Juvenile Steller sea lion Project (TJ) facilitated numerous studies through temporary captivity (branded TJs, *n*=45), with a control group sampled and released during capture events (FRs, *n*=35). Within the TJ project, the Life History Tag (LHX) project was implemented to implant individuals (*n*=35) with internal transmitters to detect individual survival and infer cause of mortality. Our goal was to evaluate long-term impacts of these two research programs on study individuals as well as identify potential markers of survival for use in field efforts. The first analysis used open-population Cormack-Jolly-Seber mark-recapture models from resights of branded individuals with demographic covariates in program MARK. LHX implanted TJs were compared to the FR control group. Overall, our results mirror previous efforts to characterize survival in sea lions and indicate minimal long-term effects from research efforts, higher survival in females than males, and increasing survival rate with age. For our second analysis, a three-tiered approach to archived data was linked to survival in TJs through similar modeling techniques. The first two levels looked at survival in relation to observed responses to handling stress through six principle blood parameters in addition to various condition indices. Change in mass (kg) and white blood cell count (WBC, m/mm^3) had the most support in predicting survival. Mass gains over captivity and slight increases in WBC resulted in a higher averaged survival rate. We also evaluated the efficacy of single-point sampling to project similar trends for field use. Minor support was identified for exit mass and entry WBC. A higher exit mass predicted a higher survival rate, while a higher WBC predicted a lower survival rate and may demonstrate the efficacy of single-point sampling as a management tool.

Long-term Monitoring of Age-specific Survival of Steller Sea Lions in Southeastern Alaska

Kelly Hastings, Lauri Jemison, Grey Pendleton

Presenter: Kelly Hastings

Email: kelly.hastings@alaska.gov

Long-term survival patterns of Steller sea lions were assessed for 7 cohorts (1994–95, 2001–05), including 2,795 known-aged animals (first marked on rookeries as pups) from 4 of 5 rookeries in southeastern Alaska, using 16 years of resighting data (2000–15) and providing age-specific information from ~ 3 wks to 21 yrs of age. Preliminary mark-recapture modeling supported senescence in survival for both sexes by 21 yrs, for animals from the largest and southern-most rookery, Forrester Island Complex (FI). Preliminary estimates of annual survival for FI females were: 0.56, 0.71, 0.88, 0.92, 0.89, 0.80, 0.72 for ages 0, 1, 2, 3–14, 15–16, 17–18, and 19–20, suggesting senescence by 17 and especially 19 yrs (-0.12 and -0.20 compared 3–14 yr olds). Senescence in FI males occurred sooner than females, with survival declining sharply from 16 to 19 yrs such that no males remained at 19–20 yrs. Preliminary male survival estimates were 0.50, 0.66, 0.82, 0.86, 0.68, 0.67, 0.50, 0.00 for ages 0, 1, 2, 3–9, 10–12, 13–15, 16–18, and 19–20. Preliminary models suggested annual variation in adult female survival was apparent only for the large, stable southern rookeries (FI and Hazy Islands), where juvenile survival was lower and pups smaller than newer and growing rookeries to the north. Maximum interannual range in adult female survival probabilities was 0.07 from 2000–14, with particularly poor survival in 2001 and 2005. We also present survival effects of age-specific behaviors (weaning status of juveniles, territoriality in males, and pupping in females) and compare these estimates to those from a sample of 537 animals first captured by SCUBA and aged by morphometrics at 2 months–2 yrs of age from 2001-09 to judge if animals captured and aged by this alternate method were representative of the larger population.

Missing Herring: Water Temperature, Relocation or Dinner?

John Moran, Jan Straley

Presenter: John Moran

Email: John.Moran@noaa.gov

In December of 2014 shoals of overwintering Pacific herring (*Clupea pallasii*) and their predators failed to return to Port Gravina, in Prince William Sound (PWS), Alaska. The failure for of this overwintering aggregation to materialize was preceded by similar event occurring in Sawmill Bay in 2010. Their high energy density, large biomass and predictable migration patterns make herring are an important forage species in the Gulf of Alaska and the main prey of humpback whales (*Megaptera novaeangliae*) in PWS during the fall and winter months. Large shoals of herring have consistently overwintered in Port Gravina since at least 2008, when we began been monitoring humpback whale predation on herring. Avian and mammalian predators feed upon these shoals during the fall and winter months when little alternative prey is available. During our December 2014 survey we did not locate any large schools of overwintering herring and the number of herring predators was greatly reduced. We propose three explanations for the absence of herring: 1) Warmer water within the Sound delayed the timing of migration, 2) Predation pressure and/or warmer water temperatures caused the herring to change their overwintering grounds, 3) Humpback whales consumed a significant portion of the herring. We will discuss the likelihood and consequences of each scenario. The 2015 spawning event also proved to be unusual, we did not locate large shoals herring typical of the area in spring, whales were present, but targeting small, fast moving herring schools. This sudden changes in a major concentration of forage fish, stresses the need for consistent long-term monitoring to detect changes that may impact local ecosystems and coastal communities.

Over-Fishing and Under-Whelming Fish: Ten Things Learned About Seal and Sea Lion Declines from Captive Animals

David Rosen, Andrew Trites

Presenter: David Rosen

Email: rosen@zoology.ubc.ca

Extensive field research has not lessened the debate about whether the modern decline of seals and sea lions in the Gulf of Alaska and Bering Sea was caused by changes in fish quality (indicative of climatic change) or availability (indicative of fishing effort). For two decades we have used trained Steller sea lions and northern fur seals to rigorously test the physiological viability of these hypothesized causes of observed population declines and assist in interpreting data acquired from wild animals. To date they have shown us that (1) there are significant differences in the nutritional and energetic value of major prey items and (2) there is no direct nutritional benefit in eating a diverse diet. (3) Pinnipeds receive even less benefit from low-quality prey once it has been digested. (4) The food requirements of pinnipeds vary dramatically during the year, leading to seasons where they are more susceptible to food shortages. (5) The physiological consequences of episodes of nutritional stress and the ability to recover are highly seasonal-dependent. (6) While individuals can increase their food intake to compensate for differences in prey quality, the amount of low-quality prey required may be more than they can physically process. (7) If sufficient energy is obtained from prey, prey quality has no direct impact on health. However, if insufficient energy is obtained from prey (due to decreased availability or quality or increased requirements), low prey quality has additional negative physiological effects. (8) Unfortunately, some of our presumed physiological indicators of nutritional stress may be misleading. We have also quantified how changes in prey distribution (density, depth) leads to changes in foraging behavior and efficiency. (9) Decreases in prey density principally alters dive behavior, increasing energetic costs and reducing overall foraging efficiency. (10) Past foraging success also affects foraging efficiency; nutritional stress lowers foraging efficiency and requires even more foraging time to meet energy requirements due to increases in diving costs. The cumulative results of our research confirm the conditions under which changes in prey can result in nutritional stress of Otariids and the nature of the physiological impacts of such events.

Seasonal Patterns on Testosterone Concentration of Male Humpback Whales

Shannon Atkinson, Jan Straley, Kendall Mashburn, Kelly Cates

Presenter: Kelly Cates

Email: kacates@alaska.edu

The North Pacific humpback whale (*Megaptera novaeangliae)* population has increased since 1966 and in some regions is now greater than estimates for pre-whaling abundances. The recovery of this population is such that it has been nominated for delisting from the Endangered Species Act. The implications of a top trophic level species returning to carrying capacity will be widespread. In order to understand how humpback whales may impact ecosystems, baseline physiological parameters need to be understood. Testosterone concentration patterns and resulting reproductive behavior are areas that need to be better understood. In order to understand these questions, new and archived blubber biopsy samples were analyzed. From these analyses, a population baseline of testosterone levels was quantified across seasons and years. Samples were collected in Hawaii and Alaska and supplemented by archived samples from the structure of populations, levels of abundance and status of humpback whales (SPLASH) effort from 2004-2006. Blubber samples were analyzed using a validated enzyme immunoassay analysis. Twelve males were biopsied across successive seasons in both their breeding and feeding grounds. An additional 100 samples were analyzed to get a baseline level of testosterone in the general population and between locations. Our preliminary results suggest that there are significant differences in concentration levels of testosterone across seasons and locations. Our results also suggests that breeding activity may not be exclusive to southern breeding grounds and that males may have the reproductive capacity to breed in Alaskan feeding grounds. If, true, a growing population of males that overwinter in Alaska may add unforeseen stress to our Alaskan marine ecosystem.

Blinded by the Sound: Effects of Natural and Human-Generated Noise on Cook Inlet Beluga Whales

Judy Jacobs, Manuel Castellote, Greg Balogh, Barbara Mahoney, Mandy Migura

Presenter: Judy Jacobs

Email: judy.jacobs@noaa.gov

The Cook Inlet beluga whale is an endangered species numbering fewer than 350 individuals. Within their restricted range, these whales must cope with a number of natural and human-generated sounds in their environment. Externally-produced sounds can interfere with these whales' communication and echolocation, which they rely on to navigate and find food in the low-visibility waters of Cook Inlet. This presentation will be a “virtual” demonstration to visually-oriented human beings of what it might feel like to be a Cook Inlet beluga going about its daily routine.

A Historical Perspective on the Dietary Ecology of *Enhydra Lutris* in Southeastern Alaska

Emma Elliott Smith, Madonna Moss, Verena Gill, Seth Newsome

Presenter: Emma Elliott Smith

Email: eaelliot@unm.edu

Enhydra lutris, the sea otter, is a pivotal member of North Pacific nearshore marine communities. Ecologically important as a keystone species, sea otters are also a source of human conflict. Historically hunted to extinction in southeast Alaska (SEAK), sea otters were transplanted from remnant Aleutian Island and Prince William Sound populations in the 1960s. Subsequent population increases and local range expansions have led to conflict with macroinvertebrate fisheries. Here, we use stable isotope analysis to examine ancient sea otter diet prior to their extirpation in order to identify potential future sources of human-sea otter overlap. We analyzed stable carbon ($d^{13}C$) and nitrogen ($d^{15}N$) of ancient sea otter bone collagen from two late Holocene archaeological sites near Angoon: Daax Haat Kanada (49-SIT-244) and Yaay Shanoow (49-SIT-132). These were compared to $d^{13}C$ and $d^{15}N$ values of modern sea otter whiskers sourced from newly re-colonized populations on the north (2010) and south (2000) coast of Kuiu Island, ~100 miles south of Angoon. We find significant differences in both isotopic means and variance among ancient and modern otters. Ancient Angoon otters occupied a broader isotopic niche, and thus likely had a higher degree of dietary diversity at the population level than their modern counterparts. In particular, ancient otters appear to have more heavily utilized prey with enriched $d^{15}N$ values, such as sea cucumbers and scallops. As sea otter populations increase in SEAK, we may see further dietary expansion into these resources. In the future we hope to expand this study to include a greater number of archaeological sites along both the outer coast and inside passages of SEAK.

Community-Based Harvest Monitoring of Subsistence Harvests of Harbor Seals and Steller Sea Lions

Joni Bryant, Bernadine Erickson

Presenter: Bernadine Erickson

Email: bernadineerickson1@gmail.com

Harbor Seals (*Phoca vitulina*) and Stellar Sea Lions (*Eumetopia jubatus*) have long been a major source of subsistence food and raw materials for Alaskan Native coastal communities. Alaska Natives in about 64 coastal communities harvest and use harbor seal, particularly the Tlingit of southeast Alaska and the Alutiiq and Aleut communities of the North Pacific gulf coast. Steller sea lions are regularly used in about 20 coastal communities. For the past eighteen years the Alaska Native Harbor Seal Commission, in cooperation with the Alaska Department of Fish & Game Division of Subsistence, has collected information on the subsistence harvest of harbor seals and Steller sea lions annually. The data is collected through face-to-face interviews with hunters conducted by local research assistants in each community. The data collected include the total number of animals harvested (including struck and loss), the sex and approximate age of the animals harvested, and the timing of the hunt. The information is used by the National Marine Fisheries Service to document the number of animals harvested for subsistence in their stock assessment reports. It is also available to the public and may be used by Alaska Natives and/or agencies to make better informed resource management decisions. The surveys included a question aimed for collecting traditional ecological knowledge. Respondents were asked about their perception of marine mammal population trends over the past years. These traditional knowledge questions will be incorporated into the harvest monitoring surveys as the need for information related to a specific research project or community concern.

Shifting Hot Spots: Seasonal and Pod-Specific Habitat Use by Resident Killer Whales in the Northern Gulf of Alaska

Dan Olsen

Presenter: Dan Olsen

Email: dwolsen@alaska.edu

The resident killer whale is a genetically and behaviorally distinct ecotype of killer whale (*Orcinus orca*) that feeds primarily on Pacific salmon (*Oncorhynchus spp.*) during the spring, summer, and fall. Details regarding habitat use are limited by boat surveys subject to effort bias and weather limitations, so thirty-seven killer whales were satellite tagged in the Northern Gulf of Alaska between June and October, 2006 to 2014, to assess habitat use. Core use areas were identified through utilization distributions with the R package ADEHabitat, using a biased Brownian Bridge movement model. Differences were investigated between pods, months, and years. We found distinct shifts that are highly specific to individual pods and also to temporal changes. Resurrection Bay was strongly used in June, Hinchinbrook Entrance was strongly favored in both June and July, and Montague Strait was strongly used in September and October. These temporal shifts are likely a response to the seasonal returns of salmon, yet details on the migration routes and timing for these fishes is limited. Certain killer whale pods heavily favored the narrow entrances to Prince William Sound, particularly the deep-water portions of these entrances, rather than the narrowest sections. Within Hinchinbrook Entrance and Montague Strait, areas of deep water (200-300 m) were more heavily used than areas of shallow water (0-200 m). This preference is perplexing, yet could result from a predation response by salmon, or habitat that offers mixed foraging on returning salmon and bottom fishes. Certain pods also seasonally favored waters adjacent to the capes at Resurrection Bay and Kayak Island, the latter of which had previously only been documented anecdotally. Movements were recorded regularly out to, but not beyond the continental shelf break. Eight trips were documented into the long fjords of Prince William Sound, however just one pod was responsible for seven of these eight trips. Our observations suggest a high likelihood of habitat partitioning between pods, which has interesting implications if diet differences exist between pods which exhibit matrilineal social learning. Future research should investigate diet choice and relationships between core area use and habitat features.

Integration of Visual and Thermal Imaging Technologies for Monitoring and Study of Differential Microclimatic Associations of Seabirds in Alaska

Ann Eckmann, Michael Meyer, Tuula Hollmen, John Maniscalco, Richard Sherwin

Presenter: Ann Eckmann

Email: ann.eckmann.10@cnu.edu

Two types of thermal technologies were used along with Digital Single-Lens Reflex (DLSR) cameras to capture images and videos of various species of seabirds and Steller's sea lions in Resurrection Bay, Seward, Alaska. A modified radiometric thermal camera allowed us to insert thermal images over the visual images to delineate the habitat of the sampled area and create 3-dimensional projections of these thermal data. We also used a DSLR camera to capture detailed images of specific locations to use as reference images during post processing. The second type of camera included non-radiometric thermal imagers which recorded thermal videos of birds continuously throughout the sampling period. Concurrent use of all cameras provided repeatable estimates of numbers of birds on the water or assemblages of birds nesting both on rock faces and in crevices. Birds that were hidden by waves in visible images remained thermally detectable through a thermal "chimney" rising above the surface of the water. Repeatable counts of birds on cliffs were best collected in the morning before rock temperatures increased. By comparing thermal to visible images, it was possible to determine species-specific thermal partitioning and create habitat models of microclimate associations. The habitat models will ultimately help determine thermal associations and structures that support them. The black-legged kittiwakes (*Rissa tridactyla*) were located on the hottest portions of a cliff while pelagic cormorants (*Phalacrocorax pelagicus*), common murres (*Uria* aalge), and horned puffins (*Fratercula corniculata*) sheltered in cooler locations provided by variability in substrate (for example, crevices). The two types of thermal cameras greatly enhanced data that were collected with digital cameras and provided powerful insight into thermal associations. These cameras require no ambient light so they can be used at night and in low light situations when images from traditional cameras degrade. With thermal cameras, it was possible to more accurately count assemblages of birds and better understand differential patterns of distribution across the cliffs. We will continue to standardize protocols for data collection using thermal technology over a broad spectrum of ecosystems.

Black Turnstone: Evidence for a Population Decline or Shifting Migration Patterns?

Audrey Taylor, Mary Anne Bishop, Kristine Sowl, Anne Schaefer, Luis Verissimo

Presenter: Anne Schaefer

Email: aschaefer@pwssc.org

Black Turnstone is a rocky coast shorebird species that breeds almost exclusively in western Alaska and winters from SE Alaska south to the coast of California. Counts of Black Turnstones stopping at Prince William Sound's northern Montague Island during spring migration have declined dramatically in the last 20 years, despite this area being designated as an Important Bird Area for the species. The goal of this project is to understand if the observed decrease represents a possible breeding population decline or simply shifting migration patterns in the Sound. In this poster we describe our two-pronged approach to investigating this question, as well as provide first results from geolocator-based analysis of migration patterns, two seasons of fieldwork on the western Alaska breeding grounds, and a preliminary assessment of possible mechanisms of landscape and habitat change. Examination of migration patterns gleaned from geolocator data showed that Black Turnstones typically stopped over at least once along the Pacific coast of British Columbia or Alaska on spring migration, but only 2 of 20 geolocator-tagged individuals stopped within the Prince William Sound Region. Turnstone densities on transects established at Tutakoke in the central Yukon-Kuskokwim Delta in 1981 appear to be lower now than in the past, although work remains to be done to compare detection probabilities across time periods. Comparison of recent satellite imagery with historical aerial photos shows areas of salt grass habitat loss, broadening of tidal channels, and changes in "landscape wetness" that may indicate changes in breeding habitat quality for Black Turnstones.

Spatial and Temporal Patterns of Winter Marine Bird Distribution in Prince William Sound, AK

Mary Anne Bishop, Kathy Kuletz, Jessica Stocking, Anne Schaefer

Presenter: Anne Schaefer

Email: aschaefer@pwssc.org

The non-breeding season may be a critical period for seabird survival because food is relatively less available, weather is more extreme, light-levels are reduced, and water temperatures are cooler as compared to the breeding season. Prince William Sound (PWS) is located along the northern Gulf of Alaska and provides protected, ice-free habitat for wintering marine birds. However, information regarding winter seabird abundance, composition, and habitat associations is limited. From November 2007–March 2014, we conducted 27 marine bird surveys from ships of opportunity in PWS. From these surveys, we found that marine bird assemblages are significantly different across early and late winter, with differences primarily driven by variation in the densities of common murre (*Uria aalge*), marbled murrelet (*Brachyramphus marmoratus*), and large and small gulls. Marbled murrelets and gulls were recorded in significantly higher densities in early winter compared to late winter, while common murre were more abundant in late winter. We also found that species richness was higher in early winter, as compared to late winter. From these surveys, we identified three general areas of high bird concentrations within PWS: northeast PWS, Montague Strait, and the Southwest Passages. Notably, these are also areas where humpback whales concentrate, suggesting that environmental drivers such as currents and nutrients are creating persistent, favorable foraging conditions for marine birds and mammals in these areas. Collectively, these results show that the non-breeding season cannot be characterized by a single time period when describing seabird abundance and distribution. Therefore, historical surveys conducted across PWS in March may have missed the winter peak in abundance for important winter seabird species, thus underestimating the importance of PWS as wintering habitat.

Investigation of the Extensive Seabird Mortality Events along Southern Alaska Coastlines

Barbara Bodenstein, Heather Renner

Presenter: Barbara Bodenstein

Email: bbodenstein@usgs.gov

During March through September 2015, at least 25 seabird mortality events were reported across Alaska from Prince William Sound to the Aleutian Islands and Bering Sea. Estimates of the size and scope of mortality events ranged from a few (~5-10) to >100 birds found moribund or dead at one time and location over this 7 month period. The primary avian species reported included commonand thick-billed murres (*Uria aalge and U. lomvia*), black-legged kittiwakes (*Rissa tridactyla*), horned and tufted puffins (*Fratercula corniculata and Fratercula cirrhata*), glaucous-winged gulls (*Larus glaucescens*), and sooty and short-tailed shearwaters (*Puffinus griseus and Puffinus tenuirostris*). Some of these avian mortalities were concurrent with whale, pinniped, sea otter (*Enhydra lutris*), and fish mortalities throughout the summer. The remoteness of the locations where events occured made it difficult to collect precise epidemiological information as well as fresh specimens for diagnostic evaluation. Nevertheless, 78 carcasses were collected from various areas during this time frame and shipped to U.S. Geologic Survey National Wildlife Health Center. Thirty-five carcasses had diagnostic necropsies conducted to determine cause of death. The primary finding for both juvenile and adult specimens was emaciation; a few individuals also had mild to moderate intestinal parasite infections. No infectious diseases have been identified and all birds examined have tested negative for highly pathogenic avian influenza viruses and pathogenic bacteria such as *Pasteurella multocida*. Emaciation can be caused by multiple factors, including but not limited to lack of prey, internal or external stressors, and disease. Water temperatures were higher than normal in all marine waters of Alaska during the spring/summer 2015, likely related to persistent masses of warm water in the Pacific Ocean. A *Pseudo-nitzschia* bloom (the algae that causes domoic acid poisoning) in coastal southcentral Alaska was reported during summer 2015. In addition, shellfish harvest closures were issued due to detection of paralytic shellfish poisoning (PSP), in which bivalves accumulate potent neurotoxins (saxitoxins) during harmful algal blooms commonly caused by *Alexandrium* sp. marine dinoflagellates. The causes of emaciation remain unknown and diagnostic tests are in progress, including algal toxin analysis.

Food Web Ecology and Population Genetic Structure of Aleutian Terns (*Onychoprion aleutica*) in Alaska

McKenna Hanson, Douglas Causey, Sanjay Pyare, Jeffrey Frederick, Veronica Padula

Presenter: McKenna Hanson

Email: mhanson12@alaska.edu

Sea birds are the most threatened group of birds and have experienced the fastest decline in recent decades. Because sea bird population changes are good indicators of large-scale changes occurring in marine systems, it is imperative to further investigate the underlying mechanisms of their declines. Our target species, the Aleutian tern (*Onychoprion aleutica*), is a suitable subject with which to assess causes of such declines, as their populations in Alaska have declined by 93% between 1960 and 2013 (Renner, 2013). A winter migration study was launched in 2010 by capturing terns during their breeding season in Alaska and placing geolocators on them. Geolocator data provided better understanding of their movements while away from Alaska, raising questions of the potential risks they face during migration, such as poor food availability. We are building on this winter migration knowledge by further investigating the underlying mechanisms to changes using two molecular methods: population genetics and stable isotope analyses. Population genetic analyses can measure genetic variability across the entire Aleutian tern population in Alaska, as variability permits flexibility and survivability in the face of environmental stressors. Additionally, understanding fine scale population genetic structure among colonies will help us better understand movement of individuals across colonies. Stable isotope analyses will help us better understand Aleutian tern food web dynamics and variance in food availability, as this could largely influence population decline. The combined information from geolocator data, population genetic analyses, and stable isotope analyses will provide a more complete understanding of Aleutian tern ecology. Such information is critical for making important management decisions that will protect what remains of this species.

Bird Killers of Prince William Sound: A Foraging Strategy Used by Humpback Whales to Detect Schooling Fish

Jan Straley, John Moran

Presenter: Jan Straley

Email: jmstraley@uas.alaska.edu

Humpback whales (*Megaptera novaeangliae*) are capitalizing on the efforts of sea birds to concentrate herring at the surface. Humpback whales feed upon a variety of small schooling fish and zooplankton. As prey density increases energetically expensive feeding lunges become more profitable. To concentrate and capture their prey, humpbacks employ a variety of tactics, including the use bathymetric features, water discontinuities (surface, temperature and salinity), physical structures (docks and net pens), bubbles, sound (feeding call) and various body parts of foraging whales. In Prince William Sound, Alaska a study investigating the predation impact of foraging humpback whales upon a recovering population of Pacific herring, has led to a minimum of 11 encounters of humpback whales using cues from feeding flocks of birds during surveys in September, December 2014 and April 2015. Whales targeted small schools (~0.5 – 2.0m in diameter) of Pacific herring (*Clupea pallasii*, age 0 through adult) near the water's surface that were being actively attacked by gulls and diving sea birds Humpback whales were acoustically cued by frenzied feeding behavior produced by the birds and/or the herring movements below the surface. When using feeding flocks to target fish whale behavior involves fast swimming, shallow dives (without fluking), and frequent changes in direction. When a feeding flock forms (over one km away in some cases), the whale makes a course change and heads directly to the birds. Usually the whale would not surface until lunging under the fish, engulfing the fish school. A noteworthy observation occurred on April 3, 2015 outside of Stockdale Harbor. Two whales, called the "Bird Killers", engulfed and spit out 8 glaucous-winged gulls (*Larus glaucescens*). In the wake of a lunge through the flocks, the dead and dying gulls appeared to have lost their water-proofing. It is unlikely that direct mortality of birds by whale is high enough to impact bird populations. However, by consuming the entire schools of fish that have been concentrated by birds, whales may increase foraging cost for sea birds which may impact populations, especially when prey is scarce.