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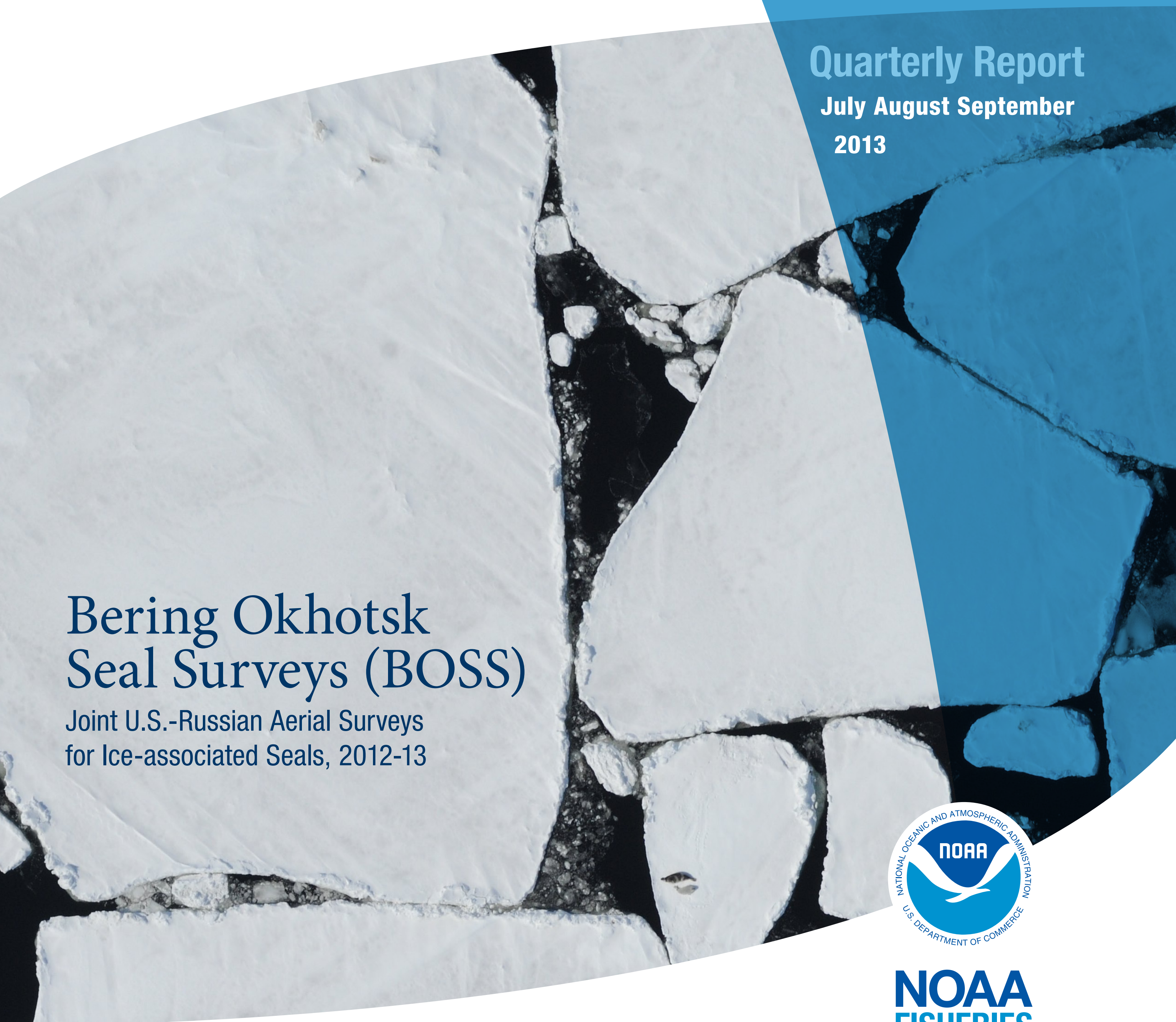

Quarterly Report

July August September
2013

Bering Okhotsk Seal Surveys (BOSS)

Joint U.S.-Russian Aerial Surveys for Ice-associated Seals, 2012-13

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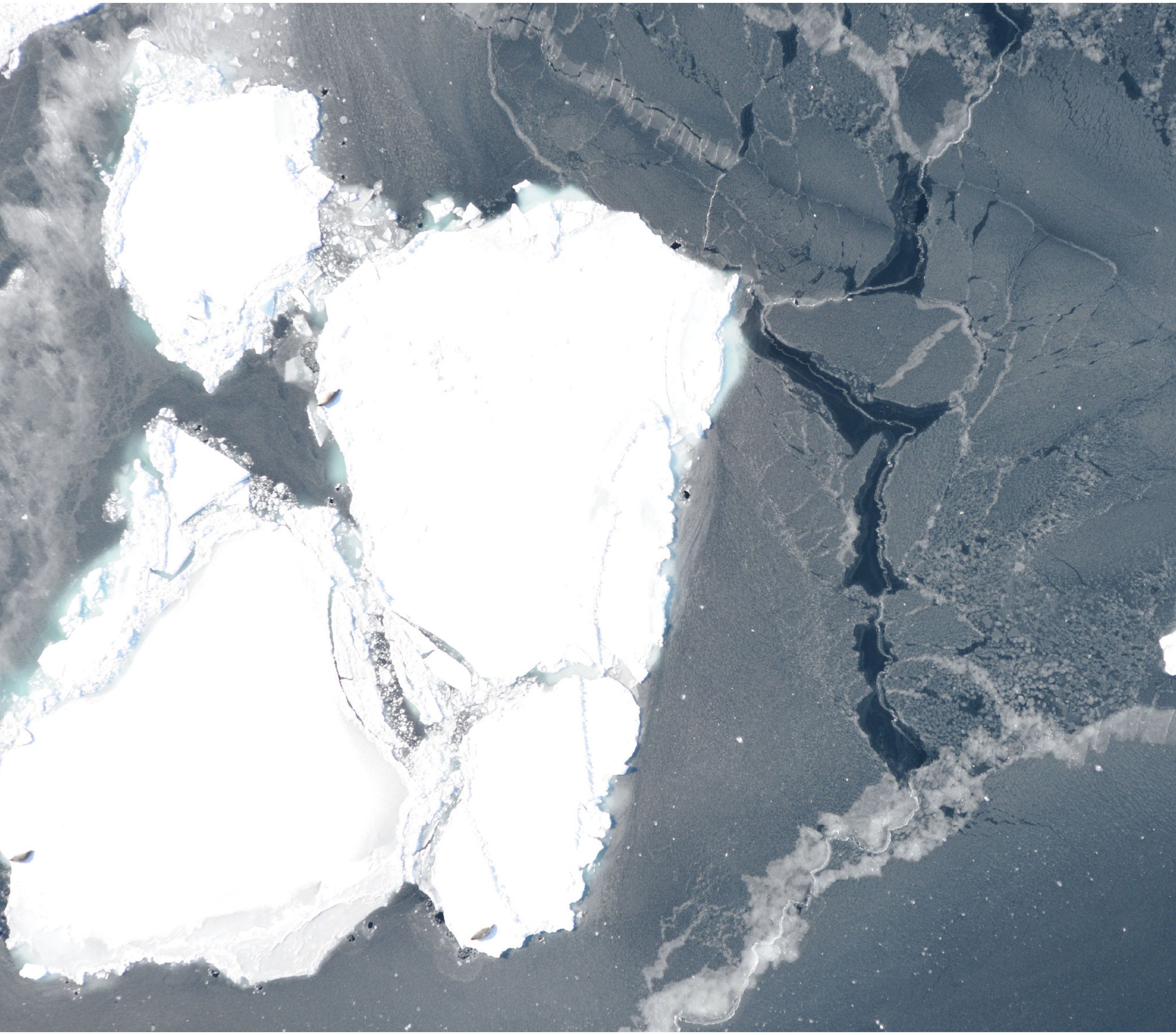

Bering Okhotsk Seal Surveys (BOSS)
Joint U.S.-Russian Aerial Surveys for Ice-associated Seals, 2012-13

By Erin Moreland, Michael Cameron, and Peter Boveng

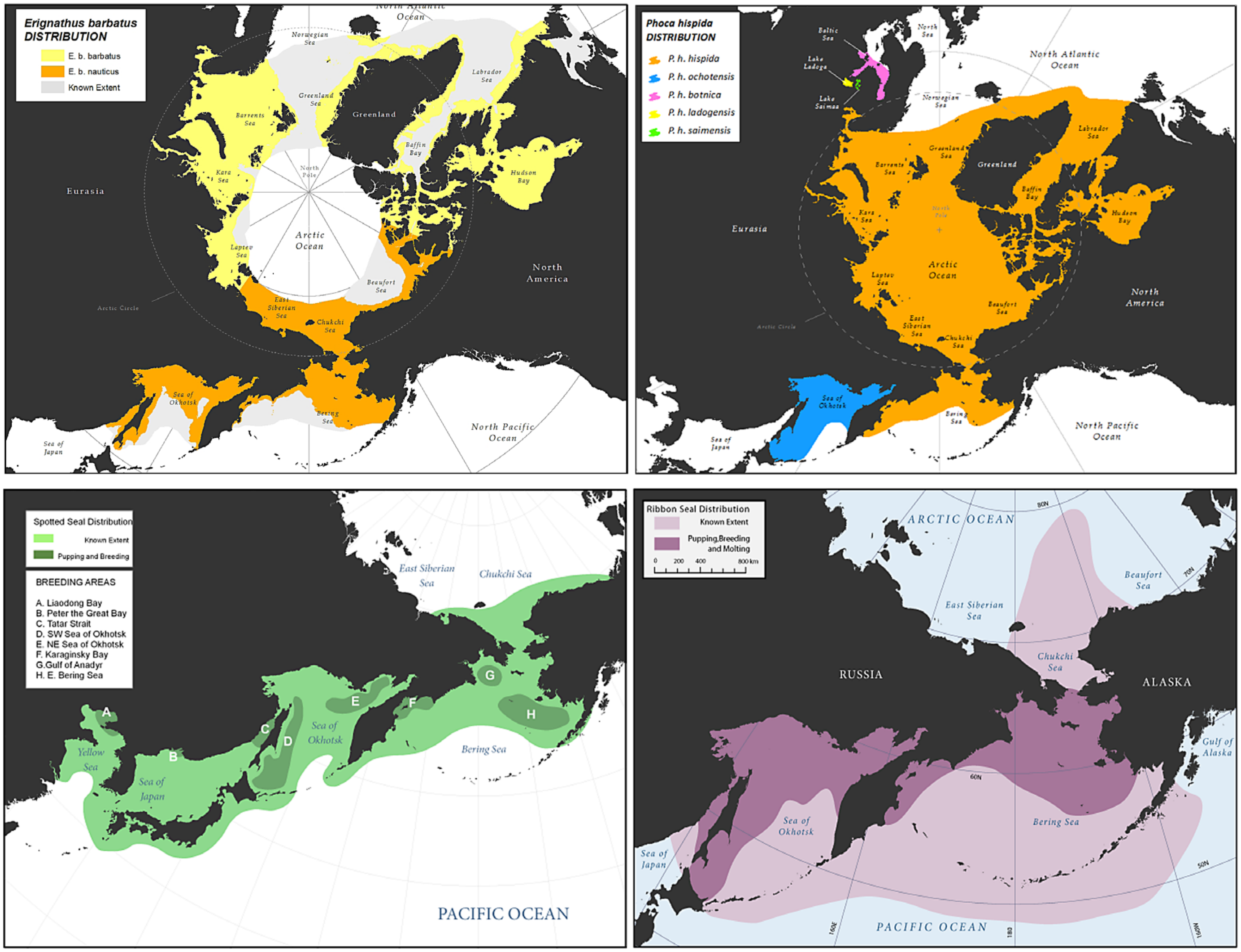

Figure 1. Distribution maps of bearded (*Erignathus barbatus*), ringed (*Phoca hispida*), spotted (*Phoca largha*), and ribbon (*Histriophoca fasciata*) seals.

Bearded, spotted, ribbon, and ringed seals are key components of Arctic marine ecosystems and they are important subsistence resources for northern coastal Alaska Native communities. Although these seals are protected under the Marine Mammal Protection Act (MMPA) and bearded and ringed seals are listed as threatened under the Endangered Species Act (ESA), no reliable, comprehensive abundance estimates are available for any of the species. Obtaining reliable abundance estimates for ice-associated seals is vital for developing sound plans for management, conservation, and responses to potential environmental impacts of oil and gas activities and climate change. The Bering Okhotsk Seal Surveys (BOSS) project addressed the most critical need for fundamental assessment data on ice-associated seals (also known as ice seals) in the Bering and Okhotsk Seas. The abundances of these species are very poorly documented. Improved monitoring of ice seals is fundamental for the National Marine Fisheries Service (NMFS) to meet its management and regulatory mandates for stock assessments under the MMPA and extinction-risk assessments under the ESA.

The best way to estimate the abundances of ice-associated seals is to conduct aerial photographic and sightings surveys during the reproductive and molting period when the geographic structure of the population reflects the breeding structure and the greatest proportions of the populations are hauled out on the ice and are available to be seen. The distributions of these seals are broad and patchy (Fig. 1), and so surveys must cover large areas. Similarly, the extent, locations, and conditions of the sea ice habitat change so rapidly that any surveys must be conducted in a relatively short period of time. The expense and logistic complexity of these surveys have been the primary impediments to acquisition of comprehensive and reliable estimates.

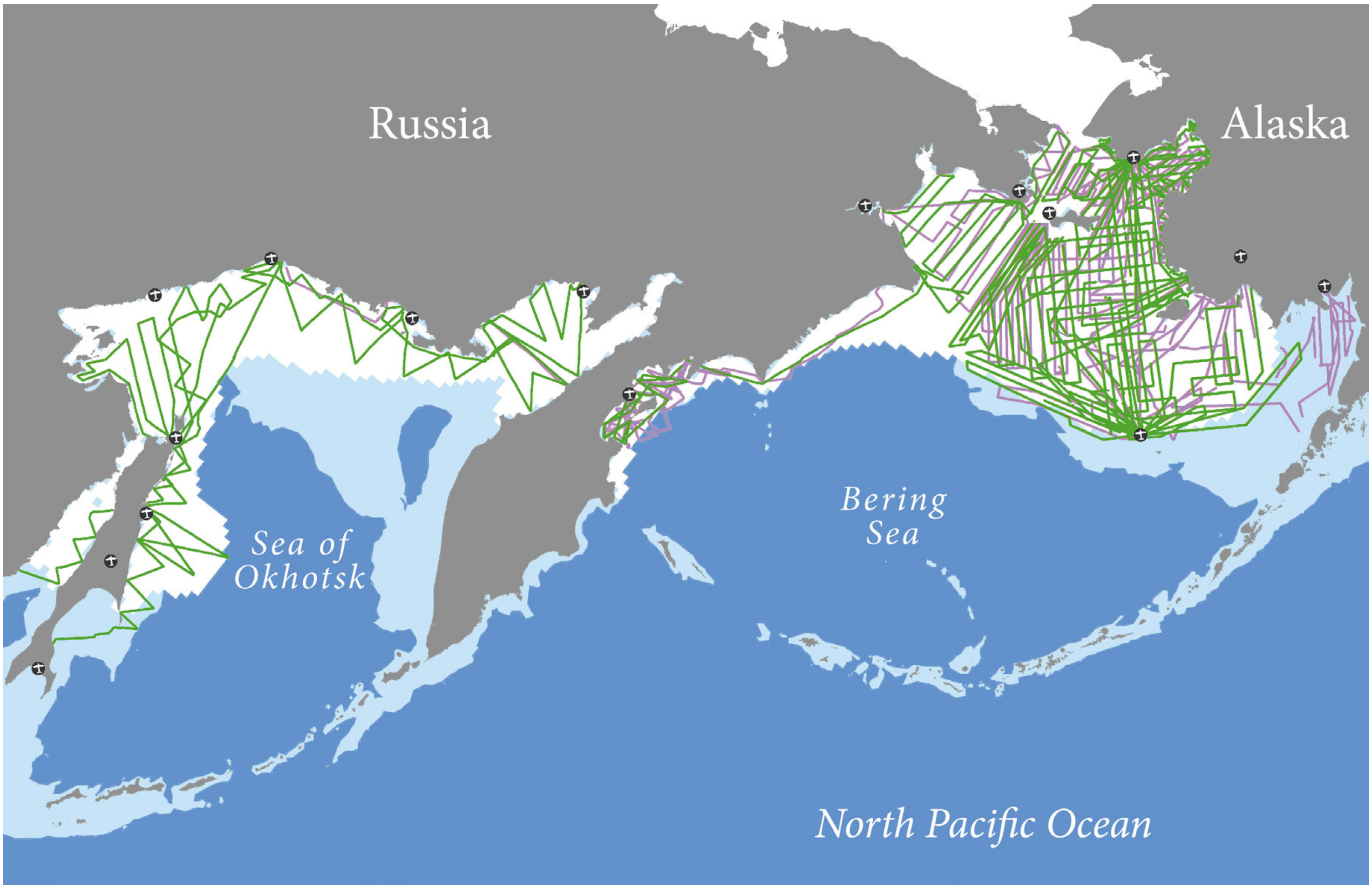

Figure 2. BOSS 2012 (pink) and 2013 (green) survey track lines in the Bering and Okhotsk seas covering more than 90,000 km (56,000 miles) completed during the joint U.S.-Russian survey effort. The 500-m isobath is in light blue and April 2013 ice extent is in white.

Scientists at the Alaska Fisheries Science Center's National Marine Mammal Laboratory (NMML) Polar Ecosystems Program (PEP) collaborated with colleagues from the State Research and Design Institute for Fishing Fleet ("Giprorybflot") in Saint Petersburg, Russia, to conduct synoptic aerial surveys of ice-associated seals in the Bering and Okhotsk Seas. Conducting spring-time surveys in those areas will yield abundance estimates for the entire population of ribbon seals, and all but a small fraction of the spotted seal population. For bearded seals, the surveys included the large and important fraction of the population that overwinters and breeds in the Bering and Okhotsk Seas. The U.S. Bureau of Ocean Energy Management provided critical financial support in 2012 and 2013 to complete the U.S. surveys of the central and eastern Bering Sea. Surveys for the portions of the bearded and ringed seal populations that breed in the Chukchi and Beaufort seas will require a separate and subsequent survey with different seasonal timing.

Two years of survey effort were required to achieve adequate precision (CV= 0.1) for abundance estimates and to ensure that sufficient periods of suitable weather occurred during survey periods. Aerial surveys for bearded, spotted, ribbon, and ringed seals were conducted in spring 2012 and 2013. In the United States and Russia combined, the teams flew more than 47,000 nautical miles (nmi) (90,000 km) of survey track (Fig. 2). The completion of this project marks the largest survey of ice-associated seals ever completed and will provide the first comprehensive estimates of abundance for bearded, spotted, ribbon, and ringed seals in the Bering Sea and Sea of Okhotsk.

Survey Effort

Surveys were conducted using digital cameras and thermal imagers mounted in the belly ports of two U.S. and one Russian fixed-wing aircraft from 6 April to 23 May 2012 and 4 April to 9 May 2013.

In 2013, U.S. surveys consisted of flights originating from airports in Nome, Bethel, and St. Paul Island, Alaska. The U.S. team also utilized an airstrip in Gambell, on St. Lawrence Island, to reach the most remote areas of sea ice in the central Bering Sea. The Russian team began Sea of Okhotsk surveys from Khabarovsk in Tatar Strait in early April 2013 and worked their way through Shelikhov Bay and into Karaginsky Bay. Surveys of the western Bering Sea began in mid-April from Ossora, Russia, on the Kamchatka Peninsula and worked their way north to the Bering Strait. The Russian aircraft carried a large, cooled thermal imager, Malakhit-M, which was paired with three fixed, digital, single-lens reflex (SLR) cameras fitted with 50-mm lenses (Fig. 3). Onboard observers also collected images with hand-held SLR cameras with zoom lenses. The Russian team completed 32 flights from 13 airports and flew more than 12,000 nmi (23,000 km).

Figure 3. BOSS 2012 Russian survey aircraft (Antonov AH-38-100) and camera setup showing a downward facing Nikon D3X and two oblique Nikon D300s. The cooled thermal imager, Malahit-M, is in a separate compartment of the aircraft.

Figure 4. NOAA Twin Otter (right) with belly port camera setup: three Canon 1Ds Mark III dSLR cameras paired with three FLIR SC645 thermal imagers.

Figure 5. Aero Commander survey aircraft and instrument setup (top): two Nikon D3X digital SLR cameras paired with two FLIR SC645 thermal imagers.

The best way to estimate the abundances of ice-associated seals is to conduct aerial photographic and sightings surveys during the reproductive and molting period when the geographic structure of the population reflects the breeding structure and the greatest proportions of the populations are hauled out on the ice and are available to be seen.

Table 1. Instrument and camera resolution of U.S. and Russian BOSS 2012 and 2013 survey efforts.

	Russian Surveys	U.S. Surveys	
Aircraft	Antonov AH-38-100	NOAA Twin Otter DHC-6	Aero Commander AC-690
Thermal Imager	Malahit-M	FLIR SC645	FLIR SC645
Digital SLR Cameras	Nikon D800, D300, D3X	Canon 1Ds Mark III	Nikon D3X
SLR Lens	50mm	100mm	100mm
Survey Altitude	200-250m	300m	300m
Thermal Swath	500m	470m	280m
SLR Swath	500m	390m	237m
SLR Image Resolution	2-7 cm/pixel	1.9-2.1 cm/pixel	2.0-2.5 cm/pixel

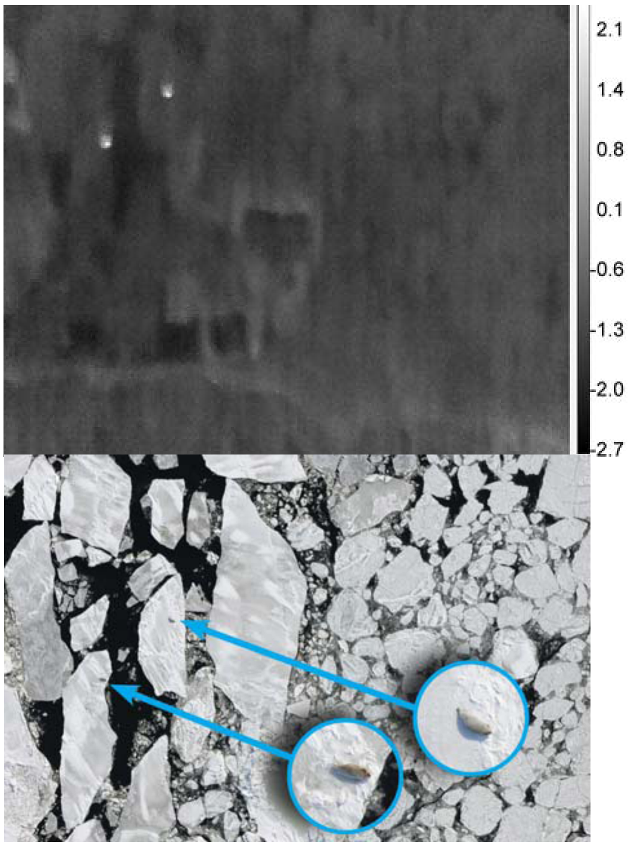

Figure 6. Example of two adult bearded seals detected using thermal imagery.

Most U.S. flights lasted 4-8 hours and were flown at an altitude of 1,000 ft (300 m) to maximize the area surveyed while maintaining the required imaging resolution and minimizing the chance of disturbance to seals and other wildlife. A NOAA Twin Otter (N56RF) aircraft housed three FLIR SC645 thermal imagers, which recorded continuous data in the 7.5-13.0 µm wavelength. Each thermal imager was paired with a Canon Mark III 1Ds digital single-lens reflex camera fitted with a 100-mm Zeiss lens. All six instruments were mounted in an open-air belly port (Fig. 4). The combined thermal swath width was approximately 1,500 ft (470 m) at an altitude of 1,000 ft. A contracted Aero Commander aircraft (Fig. 5) carried two sets of paired thermal imagers (SC645) and digital SLR cameras (Nikon D3X) and surveyed a maximum swath width of approximately 900 ft (280 m). In 2013 the two aircraft flew a total of 36 surveys covering more than 17,000 nmi (32,090 km) of trackline and collected about 913,000 images. Combined with the 2012 survey effort, the U.S. BOSS team covered 31,000 nmi of trackline and collected 1.8 million images.

Instrument-Based Surveys

The National Marine Mammal Laboratory's Bering Sea pack ice surveys for ice-associated seals have progressed from ship-based helicopter flights reliant on observer-collected data in 2007 and 2008 to instrument-only surveys on long-range, fixed-wing aircraft in 2012 and 2013. The BOSS project capitalized on recent advances in technology by pairing thermal and high-resolution digital SLR imagery. This allowed surveys to be conducted at altitudes too high for onboard observers to identify species, reducing disturbance to animals while maintaining equivalent survey swath width and allowed greater flexibility to explore species misclassification. Using long-range fixed-wing aircraft has also made it possible to achieve greater coverage of the survey area in a shorter period of time, improving our estimates by minimizing the change in sea ice habitat during the survey window.

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Advanced thermal-imaging technology was used on both the U.S. and Russian survey aircraft to detect the warm bodies of seals against the background of the cold sea ice (Fig. 6). High-resolution digital images will be used to identify the species of seals detected by the thermal imagers. Aircraft and instrument details are provided in Table 1.

Thermal Detection

Thermal detection of seals on ice has been accomplished through similar semi-automated techniques. Preliminary analysis of 2012 data for both the U.S. and Russian surveys was based on setting a temperature threshold and manually reviewing potential seal hot spots. The U.S. approach used temperature profiles to select thermal frames to evaluate (Fig. 7), while the Russian technique relied on software to identify hot spots, which were then manually reviewed and matched to SLR imagery.

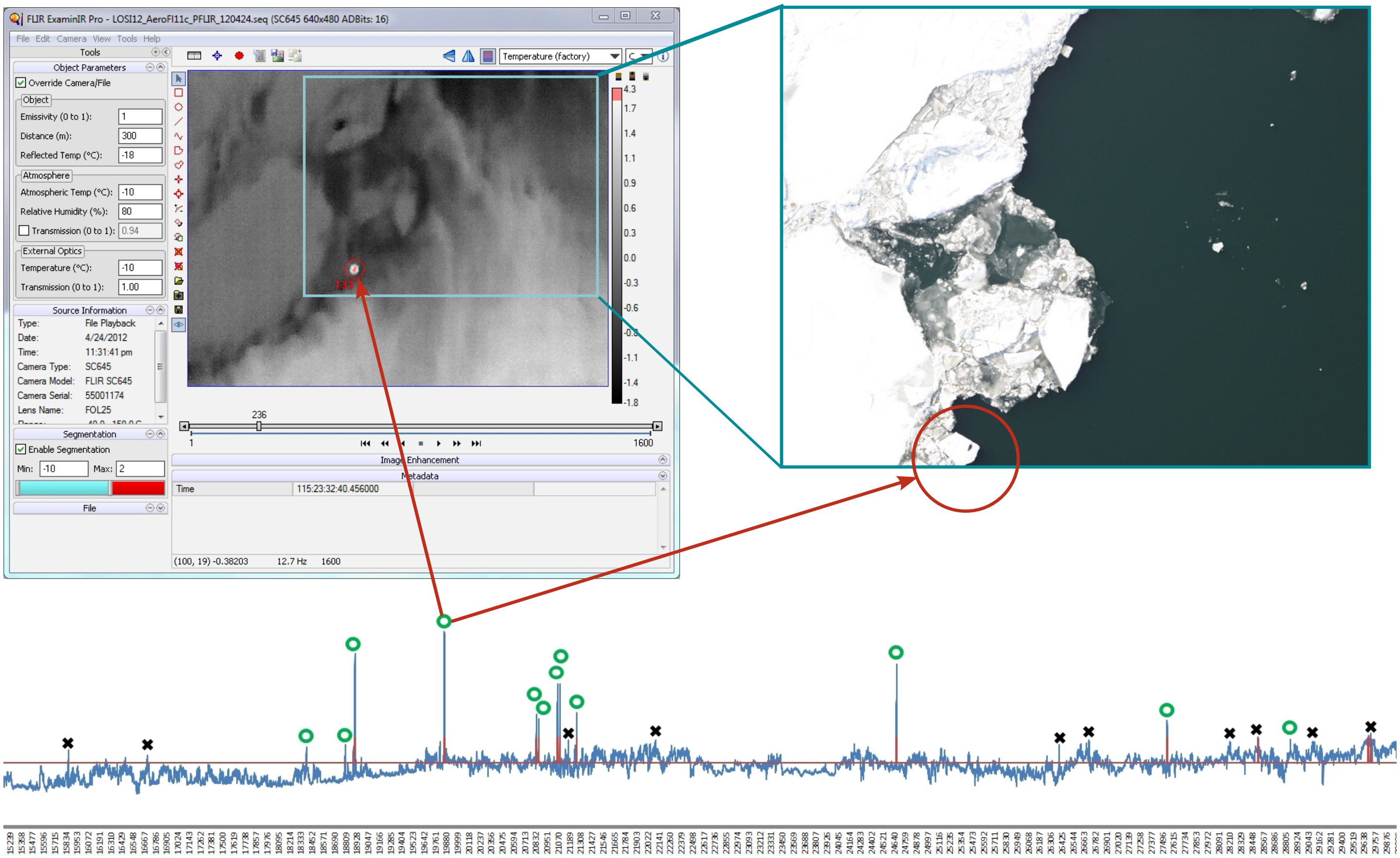

Figure 7. The U.S. hot spot detection method utilized a temperature threshold applied to a plot of maximum pixel temperature per frame to identify which thermal frames to evaluate. Digital SLR images were matched using the timestamps and ice features to locate the source of the thermal signature.

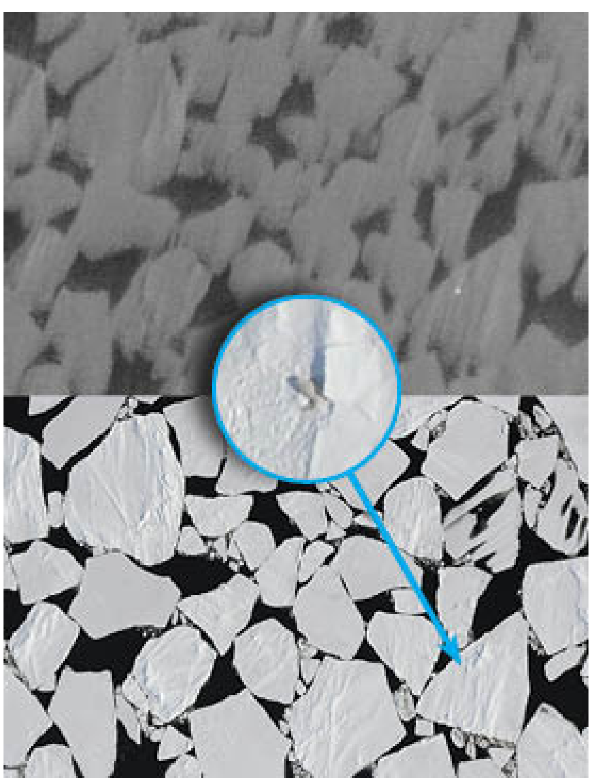

Figure 8. Example of an animal (seal pup) likely to be missed during a manual review of SLR imagery, but easily detected using thermal imagery.

High-resolution digital imagery is being used to identify seal species and differentiate hot spots generated by seals from anomalous thermal signals (false positives caused by melt pools, dirty ice, etc). These images also provide an opportunity to estimate detection probability and examine species misclassification rates. Thermal detection error for the U.S. method was determined by conducting a manual review of 10% of the SLR images included in a preliminary dataset from the 2012 survey effort (11,724 out of 117,225 images). The threshold approach detected 94% of the 70 seal groups found through manually reviewing images. In contrast, visually searching the SLR imagery for seals found 80.5% of the seal groups detected using thermal imagery. Thermal detection is particularly useful in detecting animals that are well camouflaged (Fig. 8).

Snowflake Testing

The U.S. surveys collected thermal imagery at a rate of 6 frames per second and SLR imagery at an interval of 1 – 1.4 seconds, maximizing the write speed of the camera cards. This resulted in the collection of 5.4 TB of thermal video and 1.8 million images (16.8 TB) over the 2-year project. In an effort to reduce the collection of extraneous imagery and improve efficiency of image processing, we have been exploring an automated thermal detection system called "Snowflake." This system triggers the collection of thermal and SLR images when a seal-like thermal signature is detected. The system can be used in flight or as a post-processing module to replace the threshold detection approach described above. The current version of Snowflake detects 94.5% of the seals found with the threshold detection and 98.6% of the seal groups found by manual review of SLR imagery.

Figure 9. The characteristic bands on the coats of ribbon seals are not necessarily clearly visible in an aerial image. The images on the top right and bottom right were taken with a Canon 1Ds Mark III fitted with a Zeiss 100 mm lens from 1,000 ft during BOSS 2012. In the top right image, a species identification expert would likely rely on the clearly visible bands to conclude that the seal is *certainly* a ribbon seal. In the bottom right image, a species identification expert would rely on a combination of body shape, head size, flipper size and shape, and what could be one or more faint bands to conclude that the seal is *likely* a ribbon seal.

Future improvements to Snowflake focus on reducing the false-positive trigger rate, tracking and projecting GPS data for each hot spot, and improved SLR camera control for in-flight triggering. We are also exploring machine vision cameras as an alternative to professional off-the-shelf SLR cameras. This would allow greater camera control, access to additional data to improve the filtering out of anomalous hot spots, and improved efficiency of data download, processing, and management.

Species Identification

The different characteristics that distinguish these ice-associated seal species can sometimes be difficult to discern from imagery taken at survey altitude. For example, the characteristic bands on the coats of ribbon seals will not always be visible in a photo, depending on the orientation of the seal and angle of the image (Fig. 9). The identifying characteristics of spotted and ringed seals can be even more difficult to discern from aerial photos. Although typically ignored in population estimates, errors can be common when attempting to identify similar-looking seal species from aerial photographs.

We are accounting for species misidentification in our abundance model by estimating misclassification probabilities for species identified in the images. Several ice seal experts with NMML's Polar Ecosystems Program have identified the species of more than 600 seals detected by thermal imagers and photographed during the 2012 surveys. To learn more about the factors driving the species identification process, our experts are also recorded the specific morphological characteristics that are visible in each image. In addition, experts ranked their confidence in each species identification as "positive," "likely," or "guess." By replicating the species-identification process with multiple observers for each seal, and assuming that a positive species-identification is the correct species, this allows the probabilities of correct (and incorrect) species identification to be estimated and accounted for in our final estimates of population abundance for each species.

Once this analysis is complete, not only will we have a better understanding of the frequency of ice seal species misidentification errors from aerial photos, but we also will be able to properly adjust our population estimate and variance for each species accordingly. In addition, we will gain a better understanding of the specific morphological characteristics most commonly used to identify each species from aerial transect surveys.

The different characteristics that distinguish these ice-associated seal species can sometimes be difficult to discern from imagery taken at survey altitude.

Abundance Estimation

Analyzing abundance from thermal video and digital photography presents several statistical challenges due to incomplete detection, false positives, and species misidentification. Novel statistical approaches are currently being developed by statisticians with the Polar Ecosystems Program to deal with these challenges. The process involves running a spatial model in the background describing how animal abundance varies over the survey area, while actual counts are a function of a number of additional factors including random variability and incomplete detection. For multi-species surveys, our approach handles incomplete species observations due to structural uncertainties (i.e. not all thermally detected animals are photographed) and species misclassifications. We plan to build on this hierarchical modeling framework to include a temporal dimension to account for changing sea ice conditions that occur within our survey window. The final step will be to incorporate data collected by our Russian collaborators to ultimately provide the most comprehensive estimates of abundance for bearded, spotted, ribbon, and ringed seals in the Bering Sea and the Sea of Okhotsk.

FMA Staff Present Scientific Papers at the 2013 Annual ICES Conference

The annual International Council for the Exploration of the Sea (ICES) conference was held in Reykjavik, Iceland, on 23-27 September 2013. ICES was created in 1902 to "coordinate and promote marine research on oceanography, the marine environment, the marine ecosystem, and living marine resources." The international conference provides an annual venue to present new marine research as well as discuss future scientific opportunities with colleagues in other agencies and academia. Three scientists from the FMA Division presented multiple papers at the fisheries sampling session entitled "What's the Catch? Designing and implementing statistically sound fishery sampling schemes in the real world." The objective of this session was to review the development of statistically sound sampling schemes which have incorporated practical challenges into their design and implementation, with a focus on the practicality of landing and discard estimations.

In 2013, the North Pacific Observer Program was restructured to expand the scope and improve the quality of information collected from vessels fishing in the federal groundfish and halibut fisheries of Alaska. This action provided the National Marine Fisheries Service (NMFS) the flexibility to decide when and where to deploy observers using a statistically sound sample design. The ICES conference provided an excellent opportunity for FMA to present results from several observed fisheries in Alaska with random catch sampling and several components of the 2013 sampling scheme implemented by the restructured Observer Program, including a review of current and past electronic monitoring systems utilized in lieu of human observers.

Figure 1. A North Pacific groundfish observer measuring flathead sole (*Hippoglossoides elassodon*) randomly selected from the catch on a catcher/processor trawler.

Using Random Sampling Methods To Sample Catch at Sea

Jennifer Cahalan, a NOAA affiliate from the Pacific States Marine Fisheries Commission, presented a paper discussing the viability of observers randomly sampling catch at sea on different types of vessels using several different fishing gear types. Sampling catches on commercial fishing vessels that are actively engaged in fishing activities is a difficult task, and observers do not always have the time, storage space, or tools available to sample according to a rigorous sample design. In 2010 observers deployed into the federal Alaska groundfish fisheries began recording the sample design used for each sampled haul as part of their standard data collections. Observers also recorded instances in which they were unable to collect their intended sample as planned. Data from 2010 through 2012 clearly showed that observers are able to implement random sampling methods. The sampling designs used tended to vary by vessel type, gear type, and vessel operations. Observers most often employed a systematic random or simple random sample design to collect samples used to determine the species composition of the catches. However, in difficult sampling situations such as trawl catcher vessels, observers had to resort to opportunistically collecting samples since randomized methods could not be consistently implemented. Ms. Cahalan presented a second paper in this session on catch estimations in federal trawl fisheries, co-authored by Jennifer Mondragon and Jason Gasper from the NMFS Alaska Regional Office.

Developing and Implementing the Annual Deployment Plan

Dr. Craig Faunce presented two papers in the fisheries sampling session summarizing the design and implementation of the restructured observer program. Prior to 2013, observer coverage in Alaskan fisheries was funded by commercial fishers at coverage rates set in federal regulation. Operators “self-selected” which fishing events would carry observers, providing a mechanism for biased observer data. A change in observer deployment and funding was initiated in 2008, which involved 53 persons and took 5 years to complete. Observers are now deployed onto vessels and into processing facilities according to an Annual Deployment Plan (ADP) that is developed annually by the Federal Government with public review. Although various concessions to the design were made to improve the salability of the new program, the 2013 ADP still incorporates sampling (deployment) frames with randomization to control bias. The second paper described the online implementation of the ADP using computer applications developed by coauthors from FMA; Paul Packer, Martin Park, Glenn Campbell, and Doug Turnbull. This ADP assigns fishing operations to deployment strata which randomly selects fishing trips and vessels for observer coverage. The Observer Declare and Deploy System (ODDS) facilitates the logging of trips by vessel operators in trip-selection, determines the protocol and appropriate probability of selection for that trip, and returns the outcome to the user. In contrast, vessel-selections are performed every two months based on past fishing activity. Selected vessels may petition the Federal Government for an assessment and a conditional release from coverage may be granted. The Vessel Assessment Logging System (VALS) facilitates the petition, stores information on the site visit, and constitutes a database on conditional releases. These computer applications provide the necessary data to evaluate observer deployment (and sampling) efficiency of the observer program in near real-time.

Figure 2. A North Pacific fisheries observer collecting random species composition samples from the catch.

Electronic Monitoring Systems in the North Pacific

Farron Wallace presented a fifth paper on electronic monitoring systems as a potential alternative to human observers in the North Pacific. Electronic monitoring (EM) is considered an important potential tool for fisheries monitoring onboard small catcher vessels due to the logistical and economic difficulties of accommodating an observer. In an effort to better inform future implementation of EM, a literature review was conducted on all past EM studies. Of the 59 EM study summaries located, 6 were published in peer review journals with the remaining either presented to the funding organization or published as a technical report. Sixty-three percent of the studies focused on catch composition, which requires species composition identification and quantification. In nearly all cases where species composition data was collected, video data quality was found to be inconsistent or missing for at least a portion of the study, thus degrading the ability to reliably distinguish species. Addressing these issues will be an important consideration prior to implementing an EM program in the North Pacific.

Conference summary and theme session reports can be found at: 2013 ICES annual science conference. Full conference proceedings and extended abstracts will be available soon.

By Liz Chilton

Jeff Napp is Appointed New RACE Division Director

It is with pleasure that the Center announces the selection of Dr. Jeffrey Napp as the Director of the Center's Resource Assessment and Conservation Engineering (RACE) Division effective 11 August 2013.

Jeff earned undergraduate degrees in oceanography and zoology from the University of Washington and a Ph.D. in oceanography from the University of California San Diego, Scripps Institution of Oceanography. After graduate school he spent 4 years investigating interactions between zooplankton and physics in the Atlantic Ocean at the University of Miami before first joining the AFSC's Recruitment Processes Program in 1990, and then becoming the Program Manager in 2001, succeeding Art Kendall.

Since 1990 Jeff has worked in all three of Alaska's large marine ecosystems trying to understand how weather and climate affect the distribution and abundance of zooplankton prey for planktivorous fish, seabirds, and mammals. In doing this, Jeff has been a tireless champion of research collaborations, co-directing with Dr. Phyllis Stabeno (Pacific Marine Environmental Laboratory) NOAA's Fisheries Oceanography Coordinated Investigations (FOCI) program and initiating a new interdisciplinary line of funding within NOAA for Climate Regimes and Ecosystem Productivity. Most recently, he and Dr. Stabeno worked with AFSC scientists Mike Sigler, Ed Farley, and Kerim Aydin to form an alliance between FOCI and the Center's Ecosystem Monitoring and Assessment and Resource Ecology and Ecosystem Modeling programs. One goal of the alliance is to better coordinate the Center's recruitment processes and ecosystems research. Jeff also serves on the national Bering Sea Project Science Advisory Board.

The Center is fortunate to have someone of Jeff's stature step in to take on the responsibility of leading the RACE Division. We welcome him into his new position.

By Steve Ignell

Resource Ecology & Ecosystem Modeling Program

Climate Impacts on Spawning Stock-recruitment Relationships from Multi- and Single-species Stock Assessment Models

As part of a management strategy evaluation for the Bering Sea, AFSC scientists Drs. Aydin, Holsman, and Ianelli recently investigated the relationship between climate (i.e., water column temperature) and productivity (i.e., spring and fall zooplankton biomass) on spawning stock and recruitment relationships for three species of groundfish: walleye pollock, Pacific cod, and arrowtooth founder. For this approach, recruitment estimates were first derived from a multi-species stock assessment models (MSM) fit to historical survey and fishery data.

The model was run in multi-species mode, where each species is linked through a predation sub-model, as well as in single-species mode, where no predation interactions occur. This produced a time-series of spawning stock biomass and recruitment from the multi-species and single-species models. Total spring and fall zooplankton biomasses (sprZ and fallZ, respectively) predicted from the ROMS/NPZ model for the Bering Sea were then used as covariates on a Ricker recruits (R) per spawner (S) curve and fit through maximum likelihood estimation to recruitment from the multi-species model (Fig. 1). Model estimates were compared via AIC and top models for each species were selected for use in projections of the multi-species model under future climate scenarios from ROMS/NPZ projections based on down-scaled IPCC climate model scenarios (Fig. 2).

By Kirstin Holsman

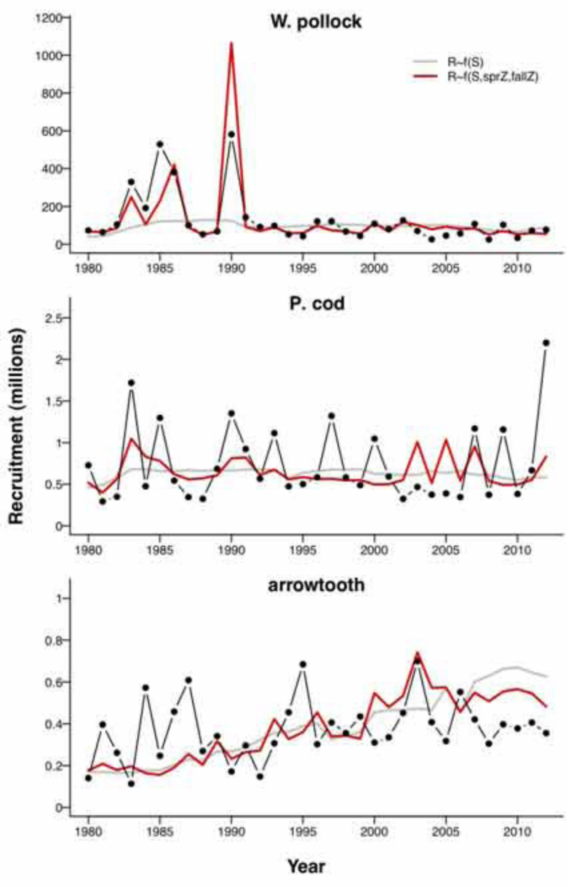

Figure 1. Recruitment estimates from the multi-species stock assessment model (black lines) and stock-recruitment regression model estimates for recruitment functions without zooplankton covariates (gray) and with zooplankton covariates (red).

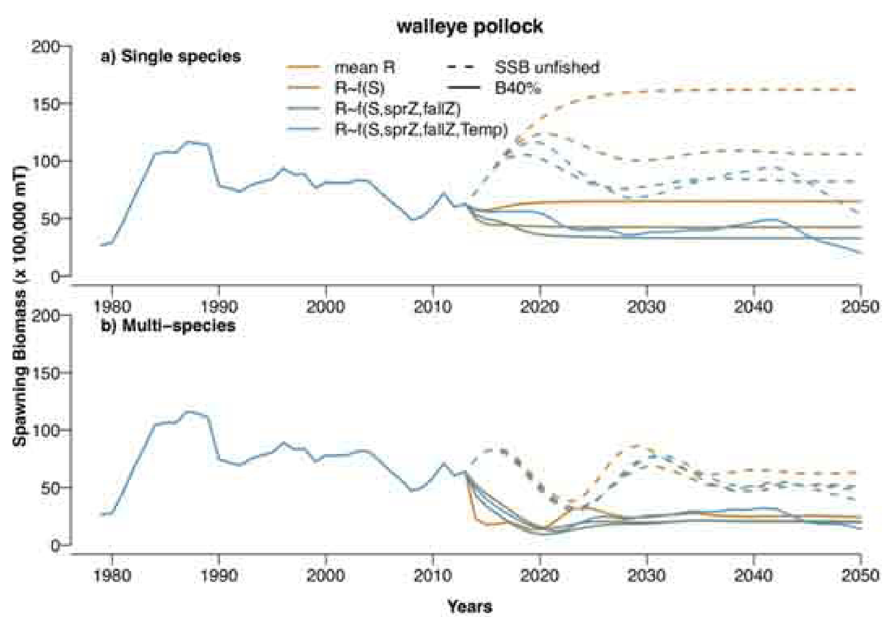

Figure 2. Projected spawning stock biomass for walleye pollock predicted from single (a) and multi-species (b) modes of MSM under various recruitment relationships and no harvest ("SSB unfished"; dashed line) or harvest that yields 40% of SSB on average during the last 5 years (2045-50) of the projection ($B_{40\%}$; solid line).

Fish Stomach Collection and Lab Analysis

During the third quarter of 2013, Resource Ecology and Ecosystem Modeling (REEM) program staff analyzed the contents of 1,816 groundfish stomachs from the 2012 Chukchi Sea samples and 2010 Northern Bering Sea samples. Laboratory analysis was completed and the resulting data was error-checked and loaded into the AFSC Groundfish Food Habits database. Analysis of stomach samples from the Aleutian Islands, Gulf of Alaska, and eastern Bering Sea has continued with and additional 1,446 records added to the AFSC Groundfish Food Habits database.

Groundfish stomach samples were collected during the AFSC's 2013 bottom trawl surveys of the eastern Bering Sea, Gulf of Alaska, and Chukchi Sea by AFSC personnel and also during commercial fisheries operations by fisheries observers. Stomach sampling focused on only five species during the eastern Bering Sea groundfish survey– walleye pollock, Pacific cod, Pacific halibut, arrowtooth flounder, and Kamchatka flounder – and 5,594 stomach samples were collected. In the Gulf of Alaska, Stomach Contents Analysis at Sea (SCANS) was performed on eight species resulting in preliminary diet data from 4,710 groundfish. Prey items that were not identifiable to the REEM minimum identification standard during SCANS were frozen and returned to the laboratory for future microscopic, and possibly genetic, examination. In addition, stomach samples were collected and preserved for laboratory analysis from 1,359 Pacific halibut caught during the 2013 Gulf of Alaska survey. Specimens from 25 species encountered during the survey of the Chukchi Sea were preserved for laboratory analysis of their stomach contents. Fisheries observers collected 555 stomach samples from walleye pollock, arrowtooth flounder, and Pacific cod in the eastern Bering Sea and from arrowtooth flounder in the Aleutian Islands region.

By Troy Buckley, Geoff Lang, Mei-Sun Yang, Richard Hibpshman, Kimberly Sawyer, Caroline Robinson and Sean Rohan

Ecosystem Committee Workshop

The North Pacific Fishery Management Council (NPFMC) Ecosystem Committee met in September 2013 to discuss 1) the need for an ecosystem-based management (EBM) vision statement for the Council, and 2) operationalizing EBM in Council projects. For the first item, several presentations summarized the Council's and NMFS' current state of ecosystem-based management, policy and science, as well as the use of EBM tools in other areas. The presentations included discussions on Integrated Ecosystem Assessments (IEA) as a tool to evaluate goals and trade-offs, the use of management strategy evaluations (MSE), and current work towards multi-species OFL (overfishing level) and ABC (acceptable biological catch) approaches, habitat approaches, and current NPFMC's ecosystem approach compared to other U.S. regions.

Kerim Aydin provided an overview of AFSC EBM support, which includes ecosystem asssessments and the development of predictive models to identify formal ecosystem thresholds, as well as linkages to IEA and MSE. For the operationalization of EBM, AFSC scientist Stephani Zador gave a presentation on the Aleutian Islands ecosystem assessment, its development, structure, and role within the annual Council process. Other operationalization projects discussed included the Arctic Fishery Management Plan, Bering Sea canyons, and coral conservation. The Ecosystem Committee's recommendations were supported by the Council, with further development expected in the coming months.

By Kerim Aydin and Stephani Zador

Economics & Social Sciences Research Program

Economic Impacts of Changes in Bristol Bay Red King Crab Fishery from Ocean Acidification

Fossil fuel emissions and deforestation have increased atmospheric CO2 concentrations, which have led to corresponding increases in oceanic CO2 concentrations, and hence, changes in carbonate chemistry of the oceans and decreases in ocean pH. Due to the increase in oceanic CO2 concentrations, the surface ocean pH has decreased on average by 0.1 units compared to pre-industrial levels. This is equivalent to a 30% increase in acidity of the surface waters. As CO2 levels continue to rise over the coming decades, the pH in the ocean will fall even further. A standard emissions scenario predicts that average pH in surface waters will fall from the current level of 8.1 to 7.8 before 2100.

This trend could have substantial physiological effects on marine organisms, affecting growth, survival, reproduction, and behavior. Calcifying organisms may be particularly affected because the reduction in pH makes it more difficult to excrete and sustain a calcified shell or exoskeleton. This will slow the growth of many marine fish species including crabs. As a result, the harvests of and, therefore, the revenue from harvests of fish species will decrease. The decrease in the revenue implies the reduction in the number of jobs in fish harvesting and processing sectors, and decrease the income of the stakeholders engaged in the fisheries. This will generate a wide range of economic impacts on fishing-dependent communities.

We used bioeconomic models and data on survival of juvenile red king crab from ocean acidification experiments conducted at the AFSC Kodiak Laboratory to estimate the linear and nonlinear effects of ocean acidification on survival parameters in stage structured pre-recruitment dynamics model; coupled the pre-recruitment dynamics model with a post-recruitment population dynamics model; and derived a sequence of Bristol Bay Red King crab (BBRKC) yield curves for an ocean acidification scenario from 2009 to 2100, using the coupled model. Using the sequence of BBRKC yield curves, we calculated the temporal and cumulative regional economic impacts of the reduction in BBRKC yields on the Alaska economy within a recursive dynamic computable general equilibrium (CGE) model for Alaska. We compared the CGE model outcomes computed with yield projections based on two different assumptions about the form of ocean acidification effects in the bioeconomic model, which represent linear and nonlinear effects on the survival of juvenile red king crab, to a baseline without ocean acidification effects.

Results demonstrate considerable uncertainty in future projections of yields and economic effects, and show that outcomes including regional economic impacts, welfare changes, and temporal changes in quota share lease rates for BBRKC are sensitive to the linear versus nonlinear form taken in the yield projections, and to changes in the world price for BBRKC.

By Chang Seung, Michael Dalton, and André Punt

Updating the North Pacific Fishing Community Profiles

Various federal statutes including the Magnuson-Stevens Fishery Conservation and Management Act and the National Environmental Policy Act require agencies to examine the social and economic impacts of policies and regulations. To meet this requirement, social scientists in the AFSC's Economic and Social Science Research Program have been working over the past year and a half on revisions to the Community Profiles for North Pacific Fisheries – Alaska. The updated profiles provide significant detail on 195 fishing communities in Alaska, with information on social, economic, and fisheries characteristics. These profiles serve as a consolidated source of baseline information for assessing community impacts in Alaska.

The community profiles include, but are not limited to, demographics, annual population fluctuation, fisheries-related infrastructure, community finances, natural resources, educational opportunities, fisheries revenue, shore-based processing plant narratives, landings and permits by species, and subsistence and recreational fishing participation. The profiles also include information collected from communities in the Alaska Community Survey, a questionnaire designed to gather information from communities about their specific infrastructure available, revenue sources, and other characteristics not available in other databases, as well as their needs and concerns related to their dependence on fishing. In addition to individual community profiles, 11 regional profiles were compiled and written, with aggregated data at the regional level.

Economic and Social Sciences Research (ESSR) staff worked with AFSC GIS specialists to develop an interactive website where the user can view high level commercial, recreational and subsistence data through a webmapping tool. Downloadable non-confidential data per community and individual community profiles are also available. This information is available on the AFSC website at http://www.afsc.noaa.gov/REFM/Socioeconomics/Projects/CPU.php.

By Amber Himes-Cornell

Groundtruthing Socio-Economic Indices of Fishing Community Vulnerability and Resilience for Alaska

Fishing communities exist within a larger coastal economy. Therefore, the ability to understand the context of vulnerability to social factors is critical to understanding how regulatory change will be absorbed into these multifaceted communities. Creating social indicators of vulnerability for fishing communities provides a pragmatic approach toward standardization of data and analysis for assessment of some of the long-term effects of management actions. Historically, the ability to conduct such analysis has been limited due to a lack of quantitative social data. Over the past 2 years, social scientists working in NOAA's Alaska, Northeast, and Southeast regions have been engaged in the development of indices for evaluating aspects of fishing community vulnerability and resilience to be used in the assessment of the social impacts of proposed fishery management plans and actions. Social scientists from the AFSC have developed indices for more thanr 300 communities in Alaska. We compiled socio-economic and fisheries data from a number of sources to conduct a principal components analysis which allow us to identify the most important socio-economic and fisheries-related factors associated with community vulnerability and resilience in Alaska in a statistically meaningful way.

We have been actively recruiting stakeholder feedback through a groundtruthing methodology to assess and refine our current suite of social indicators of community vulnerability and resilience. The new set of indices will be more accurate and also enable comparisons across regions and eventually, nationwide. This will allow cross regional analysis of fishing community vulnerability and resilience and testing of the validity of the results through in-community education and outreach. Modifications to the methodology will ultimately be made based on community feedback.

A taxonomy of fishing communities in Alaska was completed by undertaking a cluster analysis of the vulnerability indices that we previously developed. The cluster analysis results were then used to select communities to visit during our groundtruthing fieldwork. Communities were visited in the Kenai Peninsula, Kodiak Island, and Bristol Bay regions. Regional fishing industry and community organizations, including the Alaska Native and municipal governance organizations in each community, were then contacted to provide guidance on planning fieldwork trips and identifying local community members who could assist with organizing community panels, one-on-one interviews, and public meetings.

The main focus of our visits to these communities was to conduct interviews with a wide range of local residents: from those actively participating in local fisheries to fisheries service providers to non-fisheries related residents. Each interview consisted of a series of topics that were discussed with the respondent that should help us to qualitatively assess the overall vulnerability and resilience of each community to change. This qualitative assessment will then be used to validate the quantitative vulnerability indicators that we have created.

Community meetings were held in most of the communities to present the project and receive feedback from local residents on what they think of as important socio-economic pressures on their communities and how those pressures, combined with fisheries management actions and programs, are impacting their communities. These meetings were used to discuss the local significance of the concepts of vulnerability and resilience, talk with members of the community about their individual perceptions of the characteristics of their community, and discuss how this information may be effectively used to minimize the negative impacts and increase positive impacts of changes in fisheries management actions, as well as other environmental and social changes. The transcripts from these meetings will be used in conjunction with the one-on-one interviews to qualitatively assess community vulnerability.

By Amber Himes-Cornell and Steve Kasperski

The main focus of our visits to these communities was to conduct interviews with a wide range of local residents: from those actively participating in local fisheries to fisheries service providers to non-fisheries related residents.

Status of Stocks & Multispecies Assessment Program

Scientists Survey the Chukchi Sea Ocean Shelf and Canyon

A group of scientists from the AFSC, University of Washington (UW), and University of Alaska Fairbanks (UAF) surveyed the fish and invertebrate community this summer offshore of 20 m of the Chukchi Sea and into Barrow Canyon (Fig. 1). Our work was part of the Shelf Habitat and EcoLogy of Fish and Zooplankton (SHELFZ) project. The project is funded by the State of Alaska Coast Impact Assistance Program, and lead by Leandra de Sousa, of the North Slope Borough, Department of Wildlife Management, in Barrow, Alaska.

The goal of SHELFZ is to collect baseline information needed to detect and predict impacts of changing environment and increased human activities on arctic ecosystems. The focus is on areas and resources integral to subsistence communities of the North Slope of Alaska. Our work was conducted onboard the chartered commercial trawler F/V Alaska Knight, from 17 August to 4 September 2013. We surveyed the area with bottom trawls, mid-water trawls, fishery acoustics, zooplankton nets, and oceanographic instruments. The benthic community was dominated by invertebrates such as seastars, sea urchins, sea cucumbers, snails, and hermit crabs (Fig. 2). Fish, including arctic cod, sculpins, eelpouts, and snailfish made up a relatively small proportion of the benthic biomass. A small number of sub-adult pollock were caught in the bottom trawls. Acoustic data and midwater trawl catches indicated that the biomass in the water column was made up primarily of age-0 cod, jellyfish, and zooplankton such as euphausiids, copepods, and amphipods. Concurrently with our offshore survey, another group of scientists from the UW, UAF, and the North Slope Borough collected similar data inshore of 20 m, including sampling with beach seines. Together these data sets will help us understand the relationships and interactions between offshore and inshore systems of the Chukchi Sea.

By Libby Logerwell

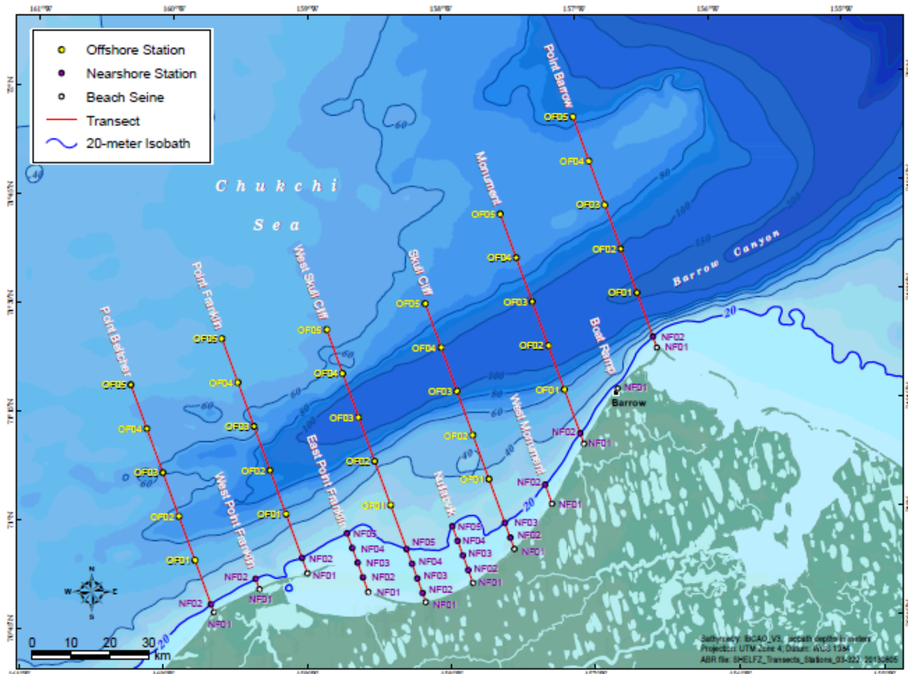

Figure 1. Station and transect locations for nearshore (purple) and offshore (yellow) components of the SHELFZ 2013 survey. Depth contours are in meters.

Figure 2. A bottom trawl catch from the offshore survey. From left to right: Troy Buckley (AFSC), Brian Beaver (F/V Alaska Knight crewmember), Alexei Pinchuk (UAF) and Roger Clarke (contractor). Photograph by Andy Whitehouse.

Collaborative Research Project with Norway

Ingrid Spies traveled to Oslo, Norway, this summer for a collaborative research project with Nils Chr. Stenseth, Per Erik Jorde, Lauren Rogers, and Halvor Knutsen at the Centre for Ecological and Evolutionary Synthesis. The project involved applying a simulation framework to answer questions about dispersal between Atlantic cod ("torsk" in Norwegian) populations along the Skagerrak coast and the North Sea (Fig.1). Atlantic cod have been economically important in this region since 800 A.D. The North Sea stock is managed by the International Council for the Exploration of the Sea and is fished by European Union states and Norway. However, there is no management plan for cod along the Skagerrak coast. Genetic population structure has been examined between the North Sea and the Skagerrak coast, but the level of population connectivity remains uncertain.

Knowledge of connectivity between stocks is important for management, as well as for predicting how stocks will respond to higher or lower fishing rates. Migration below a certain threshold can result in observable levels of genetic differentiation among marine fish stocks, while higher levels of migration may result in populations that are not genetically distinct. Non-significant genetic results may result from relatively few migrants per generation. Such a case may be problematic for fisheries managers because non-significant genetic results can be interpreted as panmixia, but ecologically distinct populations may exist. Non-significant differentiation was found between the Skagerrak coast and the North Sea, whereas differentiation was significant between the inner coast and the North Sea.

The project incorporated both biological parameters and a multi-locus genotype for each fish in a unique genetic individual-based population dynamics model. The simulation examined dispersal between two populations by varying dispersal until genetic differentiation is similar to empirical results. Results indicate that as few as 100 age-0 migrants per year may enter the outer Skagerrak and as few as 25 per year into the inner Skagerrak. Genetic differentiation was sensitive to absolute numbers of migrants, and factors that may affect the number of migrants, namely those that increase or decrease the size of the North Sea population. Differentiation in smaller populations was also sensitive to the maturity-at-age, which affected the number of individuals that contributed to the gene pool in the next generation.

Results suggest that the inner and outer fjords may be more connected to the North Sea than expected. With this level of connectivity, the North Sea may act as a source population; simulations show that both the inner and outer coast rebounded from collapse in 10 years as a result of migration from the North Sea.

By Ingrid Spies

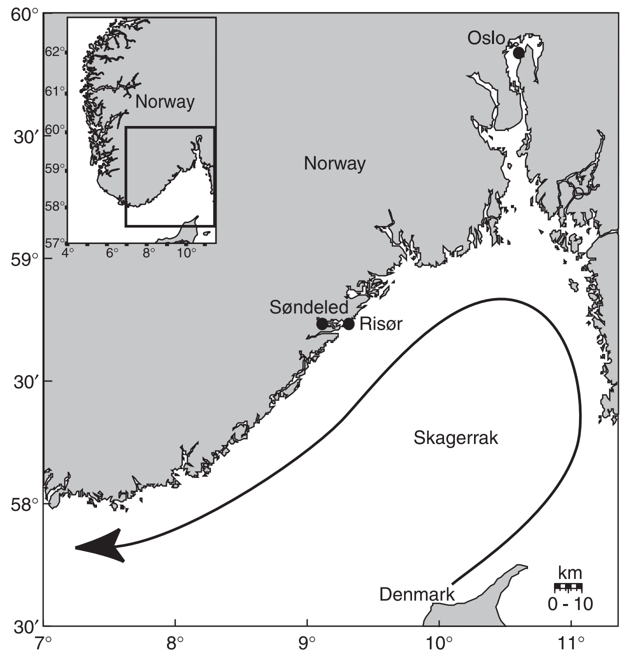

Figure 1. Map of the Skagerrak coast, with the predominant ocean current indicated by the curved arrow.

International Workshop on "Setting Biological Reference Points Under a Changing Climate"

The AFSC hosted the international workshop "Setting Biological Reference Points under a Changing Climate" on 13-15 August 2013. This workshop was co-sponsored by the Commonwealth Scientific and Industrial Research Organization (CSIRO, Australia) and the National Fisheries Research and Development Institute (NFRDI, Korea). More than 40 scientists participated from seven nations. Scientists, professors, and students from the Alaska Department of Fish and Game, Oregon State University, the University of Alaska Fairbanks, and the University of Washington all contributed to the success of the meeting. In addition, several scientists within NOAA Fisheries participated by WebEx.

The workshop focused on best practices for setting biological reference points under a changing climate. Climate change is expected to impact the distribution and abundance of fish and shellfish through direct and indirect pathways. The temporal signature of these changes is expected to differ from interannual or decadal variability and, thus, will necessitate new approaches to setting biological reference points for management. Participants in the workshop explored the potential impacts of climate change on population dynamics of key fish and shellfish populations through an examination of existing case studies. Investigators identified the range of potential management strategies to projected climate changes and to explore their implications on the future status and trends of managed species.

The workshop was structured around five central themes:

Session 1: Mechanisms underlying changes in production and analytical methods for detecting them.

Session 2: Challenges in separating the impacts of climate change from fishing and natural variability.

Session 3: Methods for quantifying uncertainty in projected changes.

Session 4: Selecting harvest strategies that are robust to, or adjust appropriately in response to, climate change induced shifts in productivity.

Session 5: Defining the precautionary approach under a changing climate.

Each session was started with one or two invited talks that set the stage followed by an extended discussion period. Results of this workshop will be published in a special issue of Fisheries Research.

By Anne Hollowed

Climate Effects on Productivity in Arctic and Sub-Arctic Ecosystems Workshop

Dr. Anne Hollowed was an invited participant in the U.S./Canada/Norway workshop "Climate effects on productivity in Arctic and Sub-Arctic ecosystems" in Reykjavik, Iceland 21-22 September 2013. Dr. Kirstin Holsman with the AFSC and Joint Institute for the Study of the Atmosphere and Ocean (JISAO) also participated in the workshop. An interdisciplinary group of climatologists, oceanographers, and fisheries scientists participated from academic and government institutions. The workshop focused on four main geographic regions: the East Bering Sea, the Northeast U.S. Continental Shelf, and the Barents and Norwegian Seas. For each of these four regions, participants identified the mechanisms that have historically been important for biological production, assessed how these mechanisms may change with climate change, and discussed consequences of changes in physics, phytoplankton and zooplankton on fish within these regions.

The workshop focused on the following key themes:

Part 1: Key physical and biological processes that have historically controlled seasonal and annual biological production in the East Bering Sea, Northeast U.S. Continental Shelf, and Norwegian and Barents Seas large marine ecosystems.

Part 2: Global climate change projections and expected physical and biological changes in the ecosystems of East Bering Sea, Northeast U.S. Continental Shelf, and the Norwegian and Barents Seas.

Part 3: Connecting climate change impacts through the food web to fisheries: Approaches, challenges, and future directions.

Invited speakers gave talks that set the stage for breakout group discussions. Results from the breakout groups were presented in plenary to provide key points for further discussion.

In Part 1 Dr. Hollowed gave a talk titled "An overview of the historical climate change and climate variability in the Bering Sea and consequences on biological productivity." The talk provided an overview of the major outcomes of the BEST/BSIERP program and introduced the current conceptual model for the mechanisms controlling biological production in the region.

In Part 2 Dr. Hollowed gave a talk titled "Projected changes in the Arctic-An overview." This talk summarized current literature on observed and projected impacts of climate change on the productivity of Arctic marine ecosystems.

In Part 3 Dr. Holsman gave a talk titled "Case studies from the Bering Sea: Integrating climate data into ecosystem and fisheries models." This talk presented recent integrated end-to-end model (FEAST) and multi-species stock-assessment model (MSM) results where climate projections have been used to derive harvest rates for Bering Sea groundfish species under climate change.

By Anne Hollowed and Kirstin Holsman

Age and Growth Program

Age and Growth Program Production Numbers

Estimated production figures for 1 January – 30 September 2013. Total production figures were 29,266 with 7,033 test ages and 259 examined and determined to be unageable.

Species	Specimens Aged
Alaska plaice	689
Arrowtooth flounder	955
Atka mackerel	1,922
Blackspotted rockfish	360
Dover sole	205
Dusky rockfish	427
Greenland turbot	2,508
Northern rock sole	864
Northern rockfish	432
Pacific cod	3,101
Pacific ocean perch	1,825
Rex sole	516
Rougheye rockfish	623
Sablefish (black cod)	2,788
Walleye pollock	11,418
Yellowfin sole	1,083

By Jon Short

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