Alaska Fisheries Science Center

Quarterly Report

JANUARY FEBRUARY MARCH 2012

Chum Salmon Bycatch in Bering Sea Groundfish Fisheries

U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Marine Fisheries Service

Alaska Fisheries Science Center

www.afsc.noaa.gov

NOAA FISHERIES SERVICE

The Alaska Fisheries Science Center (AFSC) *Quarterly Report* is produced by the Center's Communications Program. To change your delivery address or to cancel delivery, please notify: Quarterly Report, Alaska Fisheries Science Center, 7600 Sand Point Way N.E., Seattle, Washington, 98115. Phone (206) 526-4283.

Visit us on the Web at http://www.afsc.noaa.gov/quarterly/

On the cover: Immature and maturing chum salmon catch on one of the BASIS research cruises in the Bering Sea. Photo by Jim Murphy

Chum salmon buried in age-0 pollock. Photo by Kris Cieciel.

Connecting Independent Research Surveys of Bering Sea Salmon Populations to Chum Salmon Bycatch in Bering Sea Groundfish Fisheries

By Jim Murphy and Ed Farley

Introduction

Although chum salmon bycatch has historically remained at low levels relative to their biomass in the Bering Sea, recent increases in chum salmon bycatch have generated concern over bycatch impacts on Alaskan salmon stocks and the effectiveness of regulatory measures used to control bycatch in the groundfish fisheries. Member nations of the North Pacific Anadromous Fish Commission (Canada, Japan, Russia, South Korea, and the United States) developed the Bering-Aleutian Salmon International Survey (BASIS) in 2002 as an international cooperative research program designed to address concerns over the distribution, growth, and survival of salmon in the Bering Sea. By connecting information collected during BASIS research surveys to bycatch, we identify how size, foraging behavior, and foraging hotspots of chum salmon are important controlling factors of bycatch and bycatch potential in Bering Sea groundfish fisheries.

The Bering Sea walleye pollock (*Theragra chalcogramma*) fishery is the largest commercial fishery by weight within the United States. The walleye pollock fishery occurs during two distinct periods throughout the year, with the 'A' season fishery during late January to the end of March and the 'B' season fishery from mid-June to the end of October. The relative bycatch during the fishery is low, averaging approximately 1.2% of total removals by weight, compared to the estimated bycatch of 11% for all Alaska fisheries and the average nationwide bycatch estimates that approach 22% by weight. Of the 1.2% bycatch by weight in the Bering Sea pollock fishery, 24% is attributed to jellyfish while 64% consists of other quota-managed target groundfish species. A smaller portion consists of Pacific salmon (*Oncorhynchus* spp.)—mainly chum (*O. keta*) and Chinook salmon (*O. tshawytscha*). Chum salmon are primarily captured during the B season and Chinook salmon during both the A and B seasons.

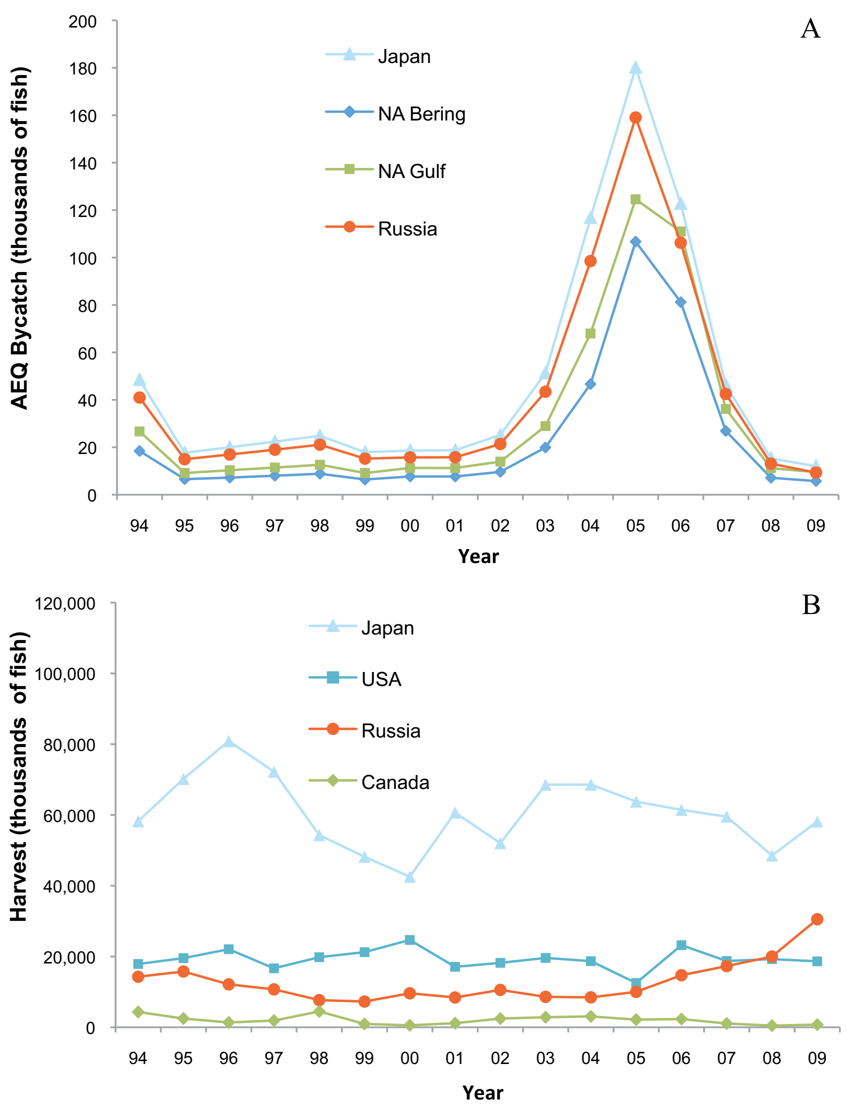


Figure 1. (A) Chum salmon adult equivalent mortality (AEQ) by the Bering Sea pollock fishery (provided by the North Pacific Fishery Management Council). Chum salmon stocks were grouped by: North American stocks from the Bering Sea (NA Bering), North American stocks from the Gulf of Alaska (NA Gulf), Japanese, and Russian stocks of chum salmon. (B) Chum salmon harvests by country (provided by the North Pacific Anadromous Fish Commission).

Pacific salmon represent an important resource to the people of Alaska and the North Pacific Rim. Within Alaska, salmon support large-scale commercial fisheries as well as subsistence fisheries, many of which form the basis of cultural traditions. Salmon bycatch management and patterns in the Bering Sea walleye pollock fishery were summarized in Stram and Ianelli (2009), and the possible effects of salmon bycatch on western Alaska communities were described in Gisclair (2009). The information presented in these papers suggests that 1) Chinook and chum salmon bycatch may impact run strength to western Alaska rivers; 2) numbers and spatial and temporal patterns of salmon as bycatch to the fishery vary substantially among years; 3) western Alaska stocks are apparently more prominent in the Chinook salmon bycatch than in chum salmon bycatch; and 4) bycatch of Chinook and chum salmon increased during 2004-06, despite efforts to reduce salmon bycatch through fixed time and area closures.

In this article we attempt to address two possible explanations for the 2004-06 increase in chum salmon bycatch (Fig. 1A). First we briefly examine whether or not an increase in overall abundance of North Pacific chum salmon could explain the rapid increase in bycatch. Next, we utilize data from BASIS research surveys to determine if a shift in their distribution occurred in the Bering Sea which may have made chum salmon more vulnerable to the commercial fishing fleet.

Chum Salmon Marine Ecology

Pacific salmon are distributed in the North Pacific Ocean and Bering Sea in summer but are primarily found in the North Pacific Ocean during winter (Fig. 2). The general migration pattern for North Pacific chum salmon stocks is to migrate to the Bering Sea from the North Pacific Ocean during spring and remain in the Bering Sea until late fall before heading south for winter. The Pacific Rim countries that have abundant chum salmon stocks include Japan, Russia, the United States, and Canada (Fig. 3). These chum salmon stocks are a mixture of hatchery and wild salmon. In fact, hatchery production of chum salmon exceeds 3.0 billion each year, followed by production of pink, sockeye, Chinook, and coho salmon, respectively (Fig. 4). Japan produces almost entirely hatchery-reared chum salmon (nearly 2.0 billion each year), whereas the other countries have a mixture of hatchery-reared and wild stocks.

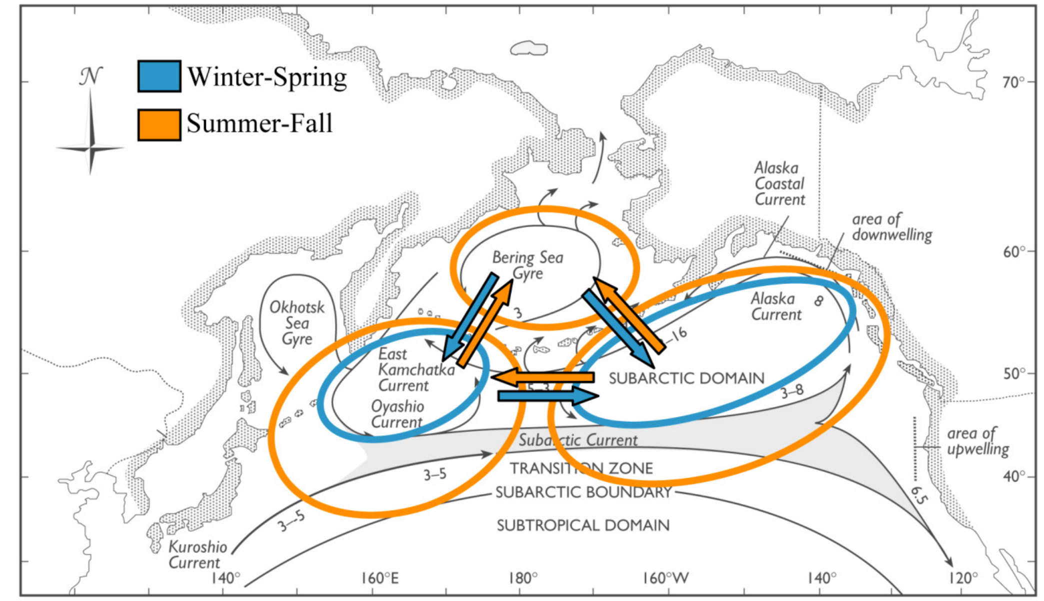


Figure 2. A general concept model of seasonal distribution and migration of Pacific salmon in the open ocean. Map is from Myers et al. (2007).

Abundance

During the summer months, immature (ocean age-1 and higher) chum salmon from all the Pacific Rim countries enter the Bering Sea to feed and grow. Some of these chum salmon are captured as bycatch during the Bering Sea walleye pollock fishery. Recent analysis of chum salmon bycatch suggests that the numbers of chum salmon caught during the walleye pollock fishery remained fairly constant from the mid-1990s to 2003 (Fig. 1A). Genetic stock composition analysis suggests that chum salmon from Japan consistently had the highest numbers of fish captured in the bycatch followed by Russian stocks, North American Gulf of Alaska stocks, and North American Bering Sea stocks. There was an increase in bycatch for all chum salmon stocks during 2004-06 followed by a decrease for all stocks during 2007-09. Harvest and production levels of chum salmon from the mid-1990s to 2009 also varied among the Pacific Rim countries (Fig. 1B). However, when comparing harvest and bycatch trends, it does not appear that the variability in abundance of chum salmon can account for the increase in bycatch in 2004-06.

Distribution

The Bering Sea has been the recent focus of marine research by the North Pacific Anadromous Fish Commission (NPAFC). Member nations of the NPAFC developed BASIS as an international cooperative research program designed to address concerns over the distribution, growth, and survival of salmon in the Bering Sea. BASIS surveys were initiated in 2002 and have occurred annually during summer and early fall months depending on the region of the Bering Sea surveyed (western, basin, eastern).

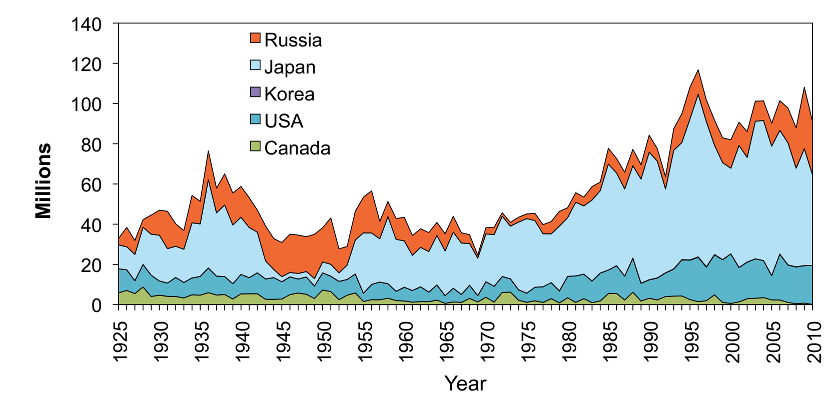


Figure 3. Chum salmon catch (millions) by country during 1925 to 2010 (data courtesy of the North Pacific Anadromous Fish Commission).

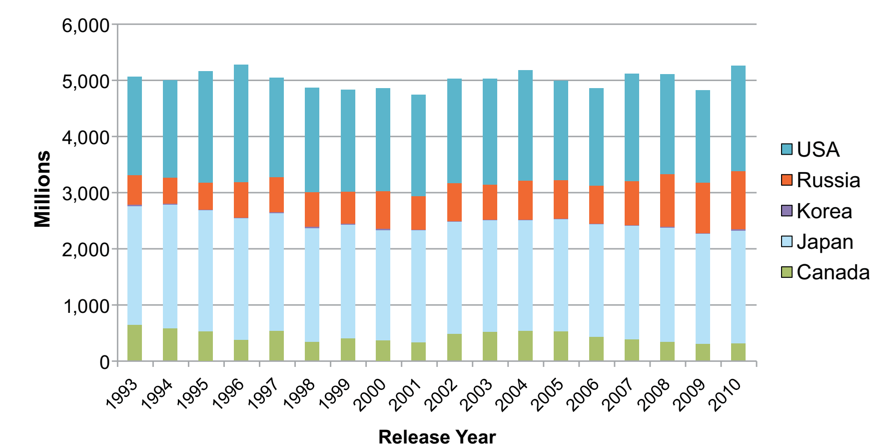


Figure 4. Hatchery production (millions) of salmon by species during 1993 to 2010 (data courtesy of the North Pacific Anadromous Fish Commission).

Chum salmon bycatch can occur throughout the fishing season, but nearly all chum salmon bycatch occurs during the summer and fall. Much of the chum salmon bycatch occurs along the outer eastern Bering Sea shelf region with hotspot locations found in the southeastern Bering Sea region (Fig. 5). However, these bycatch hotspots located on the outer shelf are in sharp contrast to the overall distribution of immature chum salmon in the Bering Sea. For instance, while BASIS surveys indicate that immature chum salmon do move onto the shelf in the northern and southern regions, the highest concentrations of immature chum salmon are found in the deeper, basin region during summer months (Fig. 6).

BASIS surveys conducted by the United States along the eastern Bering Sea shelf typically have occurred between mid-August to early October. Because these surveys have occurred later in the summer, limited connections can be made with chum salmon bycatch that occurs in the early summer months (June and July). However, peak bycatch has generally occurred during August and September and is consistent with the timing of the surveys. For instance, the relationship between chum salmon distribution and bycatch hotspots can be seen in the 2006 BASIS survey (Figs. 7A and B). Similar to the generalized offshore distribution of immature chum salmon, on-shelf movement of chum salmon is seen in both the northern and southern Bering Sea regions. Bycatch hotspots south of the Pribilof Islands correspond to locations of elevated chum salmon abundance from the BASIS survey in what appears to be on-shelf movement of chum salmon.

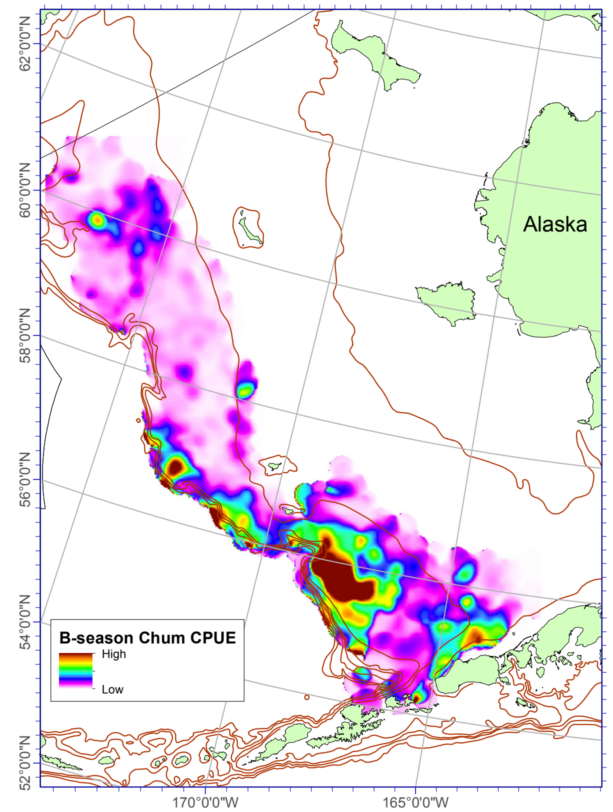


Figure 5. Mean (2003-06) catch per unit effort (number of fish per hour) of chum salmon caught as bycatch in the walleye pollock fishery. Darker color represents areas with higher CPUE.

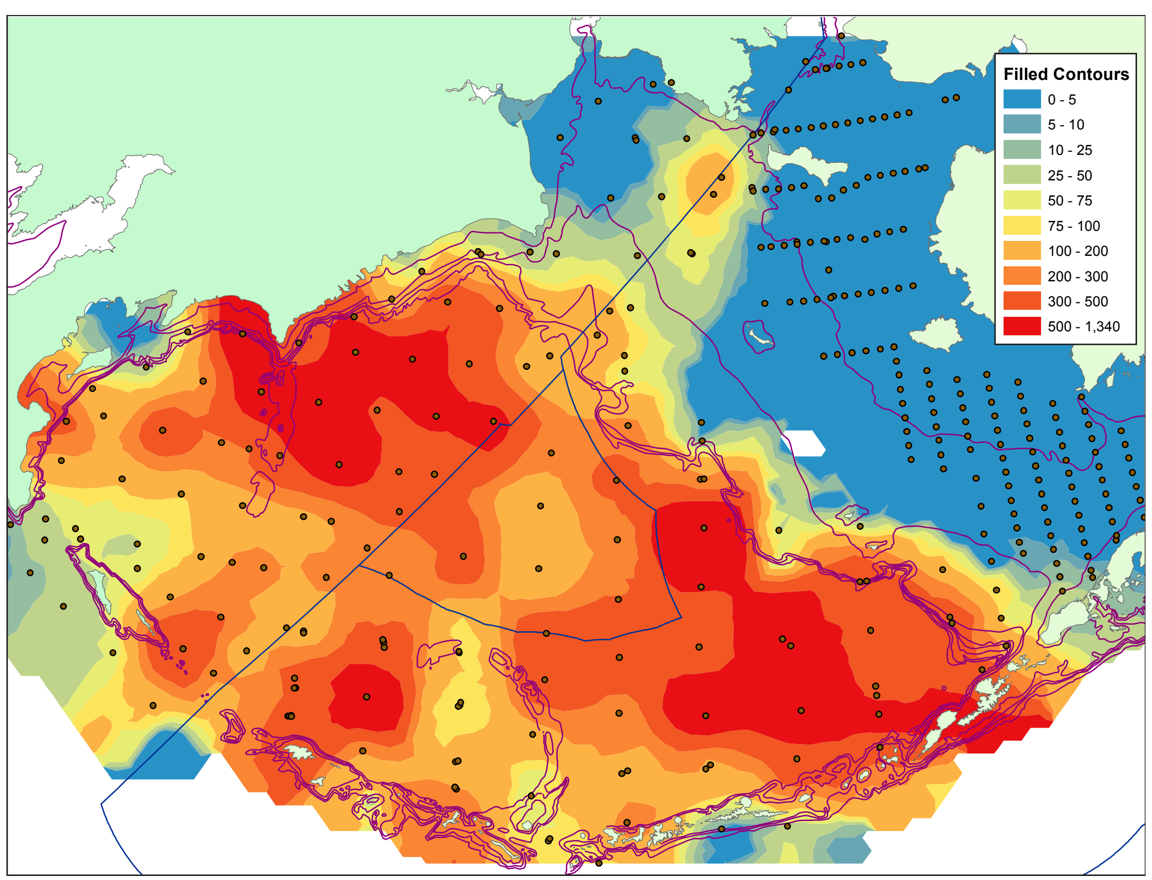


Figure 6. Distribution of immature/maturing chum salmon during mid-August to October 2002. Data are from BASIS research surveys conducted in western, central, and eastern Bering Sea during summer and early fall 2002. Black dots refer to stations sampled for salmon. Shading represents areas of no (white) to high (dark) immature chum salmon catch.

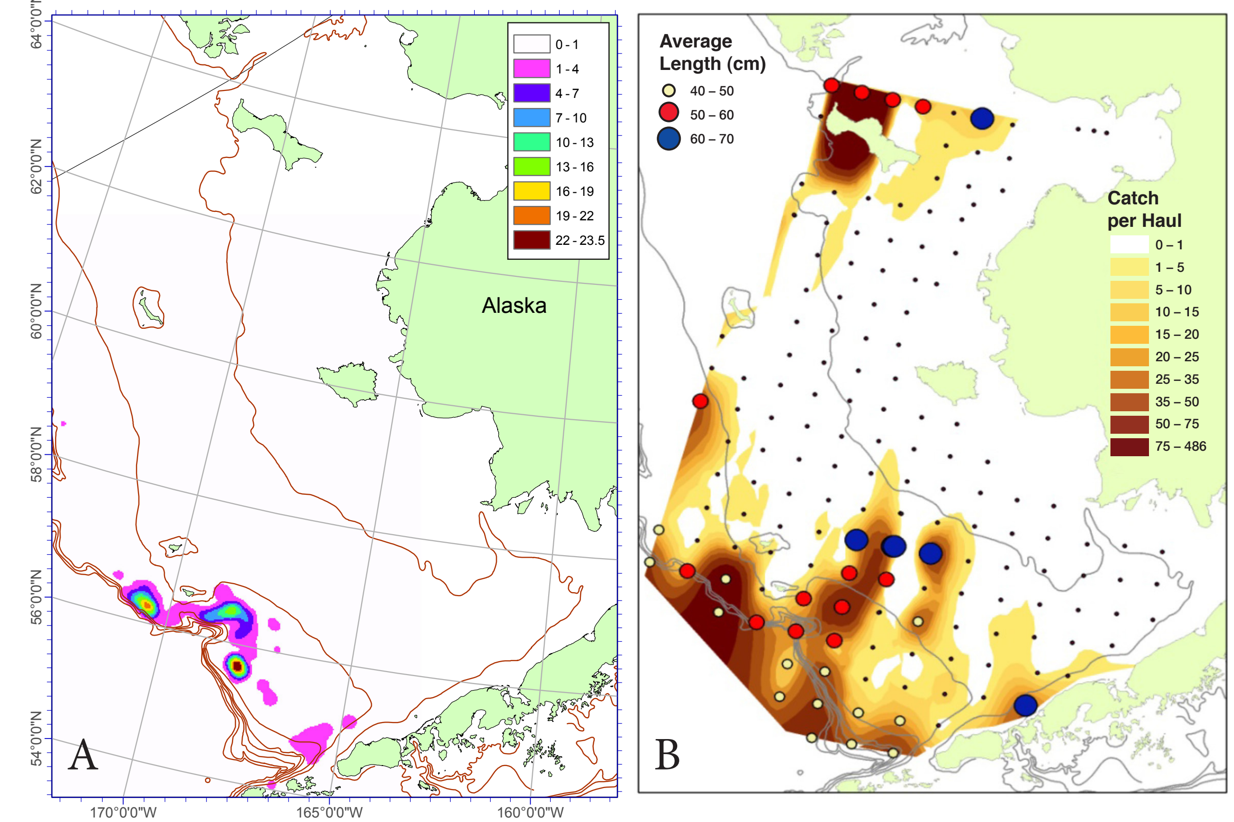


Figure 7. (A) Bycatch hotspots in Bering Sea walleye pollock trawl fisheries during August to September 2006. (B) Chum salmon distribution during the 2006 mid-August to October BASIS survey. Colored symbols in the BASIS survey distribution identify the average size of chum salmon at each location; only locations with catches greater than 20 are shown (blue: > 60 cm, red: 50-60 cm, white: 40-50 cm).

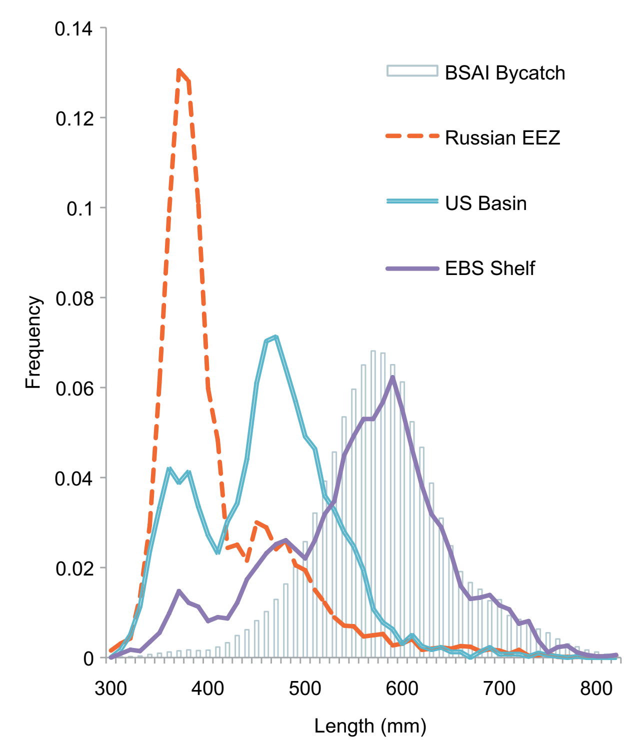


Figure 8. Length frequency distribution of chum salmon in the Bering Sea. Regions include the Russian exclusive economic zone (EEZ) (Russian EEZ), U.S. and international waters offshore of the eastern Bering Sea (EBS) shelf (U.S. Basin), U.S. BASIS on the eastern Bering Sea shelf (EBS Shelf), and the EBS shelf where chum salmon were captured as bycatch in U.S. pelagic trawl fisheries (BSAI Bycatch).

Our survey data suggest that movement of chum salmon from the Bering Sea basin onto the shelf and into the fishery is ultimately the key feature that establishes bycatch potential, whereas the ability of fishermen to avoid catching chum salmon determines bycatch. The average length of immature chum salmon from BASIS research surveys illustrates that chum salmon migrating from the basin to the shelf are composed of the largest or oldest fish (Fig. 7B). Similarly, the larger chum salmon are captured as bycatch in the pollock fishery, whereas the smallest (and youngest) fish are distributed in the western Bering Sea and across the Bering Sea basin (Fig. 8). Moreover, the large biomass of chum salmon just offshore of the fishery emphasizes that species-level movement patterns such as changes in migratory trajectories or foraging behavior, particularly by larger chum salmon, could significantly alter the overlap of chum salmon with the fishery.

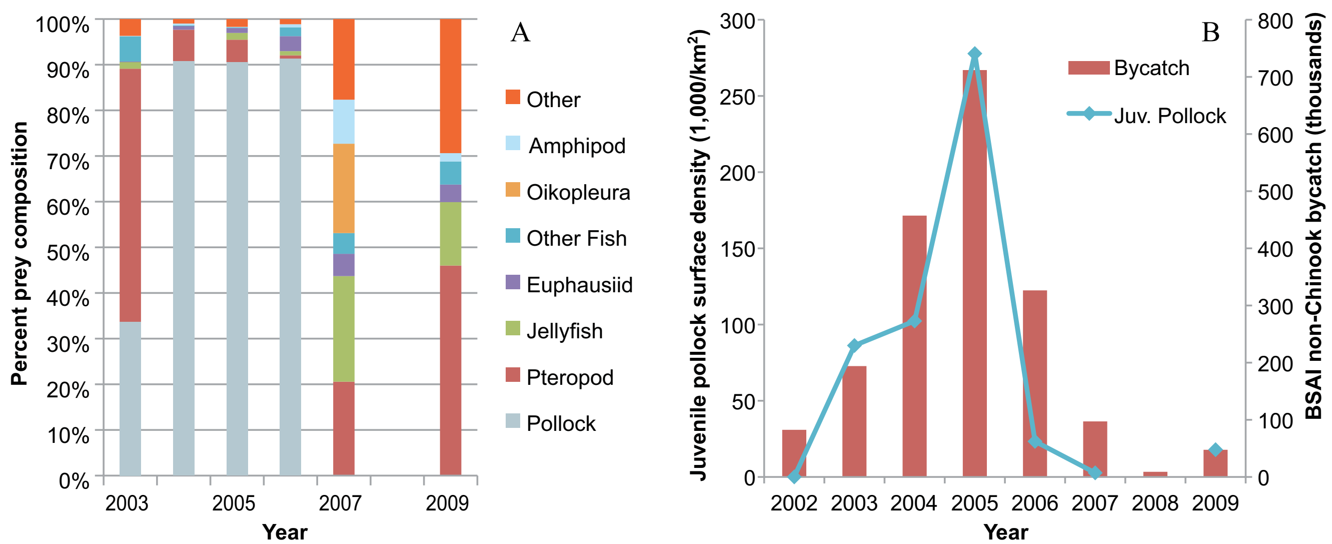


Figure 9. (A) Diet composition of immature/maturing chum salmon in the outer domain of the southern Bering Sea shelf. (B) Relationship between surface trawl catches of juvenile (age-0) pollock in the outer domain and bycatch of chum salmon in Bering Sea groundfish fisheries.

Chum salmon foraging behavior

Understanding factors affecting movement of immature chum salmon from the basin and onto the outer Bering Sea shelf is a key component to determining bycatch potential. Salmon diet and prey field information was collected each year (from 2002 to 2009) during the BASIS surveys to provide insight into the foraging behavior of chum salmon. Our data indicate that during 2004-06, over 90% of the prey (by weight) for immature chum salmon was age-0 walleye pollock (Fig. 9A). Immature chum salmon diets shifted to a mix of prey species including pteropods, oikopleura, and other items during 2007-09. Another key feature of the BASIS survey is our ability to sample pelagic fish prey such as age-0 walleye pollock and Pacific cod. The trawl used during the survey captures these fish in the surface waters (surface to 30-m depth) at depths where immature chum salmon are distributed. Based on our trawl catches, relative abundance of the age-0 walleye pollock found above 30-m depth were highest in the survey region during 2004-06.

Evening on the Bering Sea during a BASIS research cruise. Photo by Lisa Eisner.

Because these surface distributions of age-0 pollock are found primarily on the eastern Bering Sea shelf, they could be one possible factor affecting movement of immature chum salmon from the basin to the shelf region. To test this hypothesis, we related the surface densities of age-0 walleye pollock from BASIS surveys to the total bycatch of chum salmon (Fig. 9B). We note that there is a strong relationship between age-0 pollock surface densities and the total chum salmon bycatch, suggesting that peak chum salmon bycatch during 2004-06 occurred during a period of increased densities of age-0 walleye pollock in surface waters of the eastern Bering Sea. Therefore, increased chum salmon prey density in surface waters (2004-06) on the outer shelf may have been one factor driving the movement of immature chum salmon from the basin and onto the outer shelf, thereby contributing to increased bycatch potential during the peak bycatch years (2004-06).

AFSC fishery biologist Alex Andrews with maturing chum salmon captured during a BASIS research cruise in the Bering Sea. Photo by Lisa Eisner.

Conclusion

Our survey data suggest that increased bycatch of chum salmon during 2004-06 may have been an artifact of increased prey density along the outer shelf of the eastern Bering Sea. We conclude that these 'foraging hotspots' for chum salmon could contribute to an increased movement of larger (older age) fish from the basin onto the shelf, or they could simply retain chum salmon within the fishery, making them vulnerable to bycatch for a longer period of time.

Acknowledgements

The authors would like to thank the many scientists who have contributed to the BASIS surveys, particularly scientists from the Auke Bay Laboratories and the TINRO-Center, Russia, who have assisted with the U.S. BASIS surveys. We would also like to commend the excellent support of the vessels, owners, and crews who have supported the BASIS survey data presented in this article, including the research vessels *TINRO*, *Kaiyo maru*, the NOAA ship *Oscar Dyson*, and the chartered fishing vessels *Sea Storm* and *Northwest Explorer*.

References

Gisclair, B.R. 2009. Salmon bycatch management in the Bering Sea walleye pollock fishery: threats and opportunities for western Alaska. Pages 799-816 *in* C.C. Krueger and C.E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. American Fisheries Society, Symposium 70, Bethesda, Maryland.

Stram, D.L., and J.N. Ianelli. 2009. Eastern Bering Sea pollock trawl fisheries: variation in salmon bycatch over time and space. Pages 827-850 *in* C.C. Krueger and C.E. Zimmerman, editors. Pacific salmon: ecology and management of western Alaska's populations. American Fisheries Society, Symposium 70, Bethesda, Maryland.

Myers, K.W., N.V. Klovach, O.F. Gritsenko, S. Urawa, and T.C. Royer. 2007. Stock-specific distribution of Asian and North American Salmon in the open ocean, interannual changes, and oceanographic conditions. North Pacific Anadromous fish Commission, Bulletin 4: 159-177.

Sablefish Tag Program

The National Marine Fisheries Service (NMFS) has been tagging and releasing sablefish in Alaska waters since 1972. Since that time, over 350,000 anchor tags and archival tags have been released, of which more than 30,000 have been recovered.

The ABL Marine Ecology and Stock Assessment (MESA) program continued the processing of sablefish, *Anoplopoma fimbria*, tag recoveries and administration of the tag reward program and Sablefish Tag Database during 2011. The National Marine Fisheries Service (NMFS) has been tagging and releasing sablefish in Alaska waters since 1972. Since that time, over 350,000 anchor tags and archival tags have been released, of which more than 30,000 have been recovered. A total 653 sablefish tags were recovered in 2011. Eighteen percent of the recovered tags in 2011 were at liberty for over 14 years, and 10 percent of the total 2011 recoveries were recovered over 1,000 nautical miles (nmi) (great circle distance) from their release location. The fish at liberty the longest was for 34 years, and the greatest distance traveled by a tagged sablefish recovered in 2011 was 1,731 nmi. This fish was tagged with an archival tag near Umnak Island in the Western Gulf of Alaska in 1998 and recovered off of the Washington coast. Data from recovered tagged fish help provide information on the movement and growth of the fish. Eight sablefish tagged with archival tags were recovered in 2011. Data from these electronic archival tags provide information on the depth and temperature experienced by the fish.

Tags from shortspine thornyheads, *Sebastolobus alascanus*, Greenland turbot, *Reinhardtius hippoglossoides,* Pacific sleeper sharks, *Somniosus pacificus,* lingcod, *Ophiodon elongates,* spiny dogfish**,** *Squalus suckleyi, and* tagged sablefish released off the West Coast are also maintained in the Sablefish Tag Database. Fourteen thornyheads, three archival turbot tags, and three archival lingcod tags were recovered in 2011. These are the first lingcod recoveries since the start of lingcod tagging in 2007.

Releases of tagged fish in 2011 totaled 5,183 adult sablefish (including 6 with archival tags and 5 with pop-up satellite tags); 948 juvenile sablefish (including 125 with archival tags); 910 shortspine thornyheads; 45 spiny dogfish with pop-up satellite tags; 32 lingcod with archival tags; and 68 Greenland turbot (including 29 with archival tags). Potential recoveries from these tagged fish will provide invaluable information on movement, growth, and behavior of the fish.

For more information on the NMFS Sablefish Tagging program, please visit our webpage.

By Katy Echave

FMA Develops New Tools to Increase Productivity and Assure High Quality Data

As technology has advanced, we have worked to ensure that FMA has taken advantage of the powerful data management tools that are available to us in order to increase efficiency and improve data quality.

The Fisheries Monitoring and Analysis Division (FMA) works to obtain information from observers at sea, tracks the observers while deployed, provides quality control editing of the data obtained, and then distributes the data and biological samples to a range of clients within the fisheries management community. As technology has advanced, we have worked to ensure that FMA has taken advantage of the powerful data management tools that are available to us in order to increase efficiency and improve data quality.

FMA's data management and editing software systems are based on tools produced by Oracle. Three years ago the Oracle Corporation issued a statement of direction which deemphasized existing software development tools (e.g., Oracle Forms, Oracle Designer) and put ever increasing emphasis on new rapid application development strategies. Foremost among these tools are Application Express (APEX) and SQL Developer. FMA has a cadre of developers whose experience spans the gamut from complex object-oriented environments to Microsoft and Oracle proprietary languages and tool sets. With that breadth of knowledge, we chose to leverage the new suite of APEX tools and our existing knowledge base into a development strategy that supports FMA's legacy interfaces of NORPAC while deploying new state-of-the-art user interfaces. The first modules of this approach were launched for general use in December 2011.

FMA's system for capturing observer logistics information was chosen as the initial APEX module as both a good test of the technology and as an opportunity to replace an existing data model with a more robust, documented, and extensible application suite. In this process we demonstrated both the power of the new software development paradigm and provided a significant improvement in the user experience. A redeveloped module for capturing observer cruise information will allow fisheries observers to document this information electronically from any internet connection, thereby releasing observers from the restriction of only being able to complete this documentation in an FMA office. The cruise information module is undergoing final testing and will be in production by the end of April 2012.

Over the next 18 months, FMA will roll out both a new module to accommodate the Observer Program Restructure (see our article in the *October – December 2010 Quarterly Report* for more information) and redeveloped modules for data entry and final data editing. The utilization of new technology and user interfaces will streamline processes to increase productivity and efficiency and expand our information base with sound data management and quality control processes.

By Doug Turnbull and Allison Barns

Alaska Ecosystems Program

By Land, Sea, and Air: A Collaborative Steller Sea Lion Research Cruise in the Aleutian Islands

The Alaska Ecosystems Program (AEP) of the National Marine Mammal Laboratory (NMML) conducted a joint research cruise in the Aleutian Islands, 4-25 March 2012, with the Geophysical Institute (GI), University of Alaska Fairbanks, to study the winter diet of Steller sea lions (*Eumetopias jubatus*) and test the feasibility of using unmanned aircraft as a survey platform. Both Lowell Fritz (AEP) and Gregory Walker (GI) received grants from the North Pacific Research Board (NPRB) to study Steller sea lions in the Aleutian Islands—Fritz to examine the relationship between diet and population trend (NPRB project #1114) and Walker to test the use of unmanned aircraft (NPRB project #1120). Discussions began in fall 2011 to conduct the field operations necessary for both projects during a jointly-funded cruise in winter 2012, with the added benefit to NMML scientists of observing the operation of unmanned aircraft for survey purposes and to the GI team of learning more about sea lion biology and ecology. As Fritz and Walker obtained the necessary permits from the NMFS Office of Protected Resources, the Federal Aviation Administration (FAA), and the NOAA Aircraft Operations Center, it became clear that including representatives from these groups could help educate them in the operation of small unmanned aircraft for marine mammal surveys. Thus, on 4 March, the following group of 11 scientists, managers, engineers, pilots, and NOAA Corps officers boarded the RV *Norseman* in Adak, Alaska, to begin a 3-week Aleutian Islands research cruise: Fritz, Carey Kuhn, Sara Finneseth, Vladimir Burkanov, and Yura Burkanov (invited volunteer) from the AEP; Walker and David Giessel from the GI; Jay Skaggs from the FAA; Taylor Nobles from AeroVironment, LLC (makers of the "Puma," one of the unmanned aircraft tested on this trip); and CDR Nancy Hann and LTJG Van Helker (currently at NMML) from the NOAA Corps.

Figure 1. Adult female Steller sea lion (=24), with a head-mounted satellite tag, 18 March 2012, at Petrel Point, Semisopochnoi Island. Photo by V. Burkanov (NMFS MMPA research permit 14326-03). This animal was captured, instrumented, and branded on 1 November 2011 on Ulak Island.

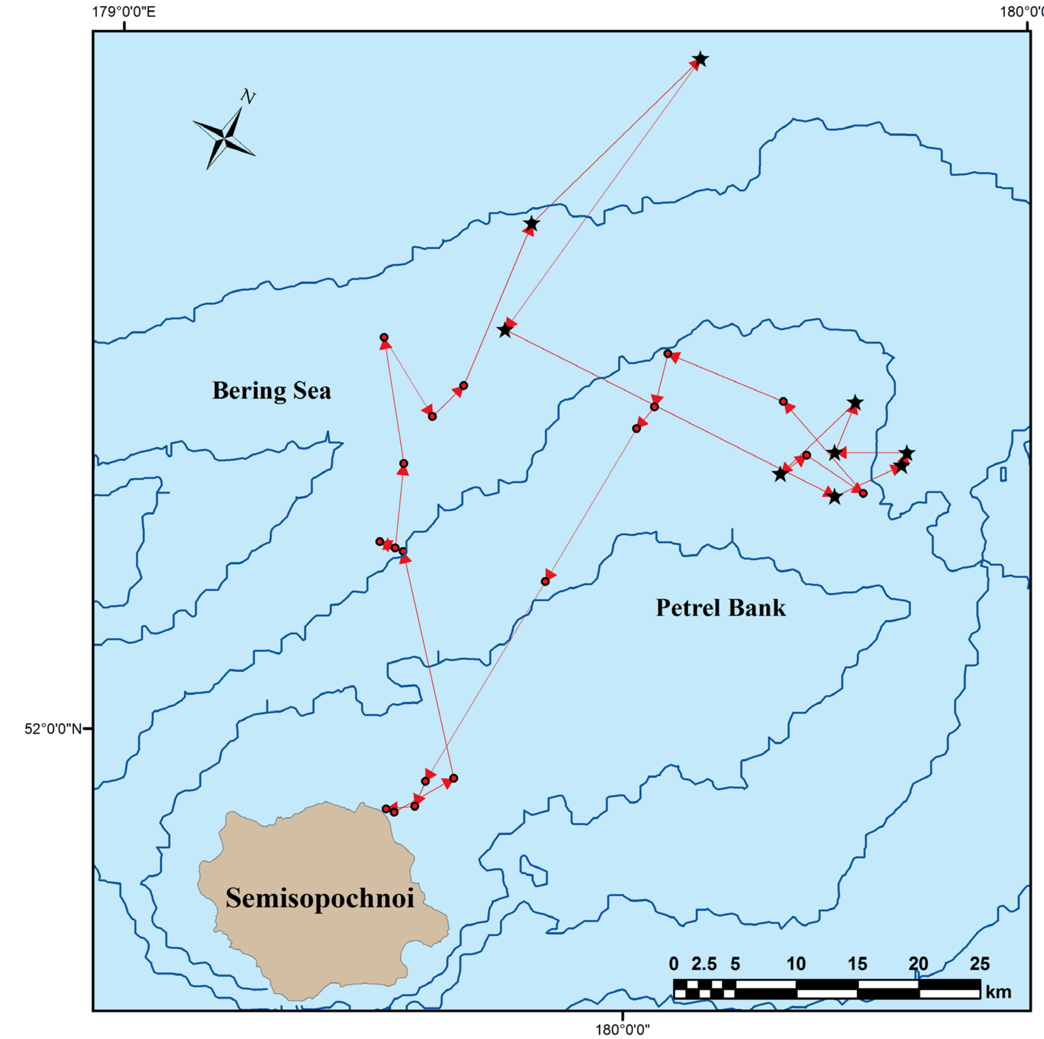


Figure 2. Movement of an adult female Steller sea lion (=24) between at-sea and on-land locations, 3-6 April 2012. The easternmost cluster of dive locations (stars) on northern Petrel Bank is where near-simultaneous sea lion diving and prey sampling by the FV Seafisher (AFSC cruise) occurred on 4 April 2012. Petrel Point is the northernmost point on Semisopochnoi Island.

In total, 54 Steller sea lion terrestrial haulout sites were visited, and almost 3,000 Steller sea lions were observed. The AEP group collected nearly 350 diet samples from 14 sites spanning the entire Aleutian Island chain from Cape Wrangell on Attu Island (172°E) to Adugak Island near Samalga Pass (169°W). In addition, they installed six cameras that will take pictures every 30 minutes during daylight hours of the rookery beaches at Cape Wrangell and Gillon Point on Agattu Island in the western Aleutian Islands. Unlike populations in the Gulf of Alaska, sea lion populations in the western Aleutian Islands continue to decline. To help promote their recovery, NMFS closed (beginning in 2011) directed fishing for two of the primary sea lion prey species (Atka mackerel and Pacific cod) in this area (NMFS regulatory area 543). Photographs at these two rookeries will provide information on the seasonal use of these terrestrial sites by sea lions and provide sightings of sea lions branded as pups on both Russian and U.S. rookeries, which will help scientists estimate survival and reproductive rates and track the movement of animals across the international boundary. During this cruise, 15 branded sea lions were observed, 11 of which were positively identified by their unique numbers: 5 were 9-month-old juveniles born and branded on Gillon Point in 2011, 3 were older animals branded as pups on rookeries as far as 1,400 nmi (nautical miles) from where they were observed, and 3 were animals captured as either juveniles or as an adult. The marked adult seen on this trip, "=24," was a lactating female that was captured on 1 November 2011 on Ulak Island (179°W) and instrumented with a satellite tag to obtain information on her movements, dive locations, and diving behavior. On this cruise, she was seen on both 7 and 18 March at Petrel Point on Semisopochnoi Island (179°E; Fig. 1), a location she had frequently hauled out on during winter 2011/12 between feeding trips to the north and east on Petrel Bank and neighboring slope habitats. AEP scientists confirmed that =24 had a dependent juvenile offspring when she was observed on 18 March. This sea lion spent considerable time diving (and presumably eating) during the winter on the northern edge of Petrel Bank (starred locations furthest to the right (east) in Fig. 2), approximately 50 km northeast of Petrel Point. In late March 2012, the catcher-processor FV *Seafisher* began an Atka mackerel tag-recovery cruise on Petrel Bank for the Center under the direction of Susanne McDermott. On 4 April 2012, the *Seafisher* used both hydroacoustics and bottom trawls to sample the fish community at approximately the same time and location where =24 was diving (starred locations in Fig. 2). To accomplish this, the AEP sent near real-time position updates for =24 to the *Seafisher,* which found that she was likely feeding on Pacific ocean perch, walleye pollock, and Atka mackerel located at the head of a canyon.

Figure 3. Steller sea lions on East Cape, Amchitka Island, 9 March 2012. This photo was taken with the Aeryon Scout quad-copter by Gregory Walker and David Giessel, Geophysical Institute, University of Alaska Fairbanks, with a GoPro Hero (11 mega pixels) camera equipped with a 170° fish-eye lens. The legs of the quad-copter are visible in the upper right and left of the image (NMFS MMPA research permit 14326-03).

The GI, NOAA Corps, AeroVironment, and FAA unmanned aircraft team conducted 39 flights surveying Steller sea lion terrestrial haulouts in the Aleutian Islands. Missions were flown under 525 ft in altitude when over land and generally under 300 ft on approach to the sea lion haulout. Animals on haulouts were photographed obliquely from just offshore, and island haulouts were often circled. Two types of unmanned aircraft were tested during this cruise: the "Aeryon Scout," a small battery-powered quad-copter, with a flight duration of 20 minutes, equipped with a GoPro high resolution real-time video/still camera on a gimbaled mount; and the Puma, a fixed wing (10-ft wingspan) battery-powered aircraft, with a flight duration of 2 hours, equipped with real-time video as well as infrared and visual still-photo capability. The Scout flew 30 missions on 10 days over 12 sea lion sites and was launched and retrieved from both the vessel and from land. It took thousands of photos of sea lions (e.g., Fig. 3) and was able to take enough overlapping photos at several important summer breeding locations to produce three-dimensional maps. The Puma flew nine missions on 7 days over nine sea lion sites (Fig. 4). This aircraft was hand-launched from the vessel and was retrieved by landing it in the water. The flights during this cruise were the most extensive to date to test the use of unmanned aircraft to survey Steller sea lions, and they provided valuable baseline information on animal response, survey techniques, and flight operations from land and vessels in the Aleutian Islands.

Figure 4. Steller sea lions on East Cape, Amchitka Island, 9 March 2012. This photo was taken with the Puma fixed-wing unmanned aircraft by Taylor Nobles, AeroVironment. The infrared image shows warm animals (black) on colder rock substrate (white) (NMFS MMPA research permit 14326-03).

By Lowell Fritz

Cetacean Distribution and Abundance in Relation to Oceanographic Domains on the Eastern Bering Sea Shelf in June and July of 2002, 2008, and 2010

The eastern Bering Sea (EBS) shelf is a highly productive ocean region, which responds rapidly to changes in climate. Because of its economic and environmental importance and climate sensitivity, the U.S. National Science Foundation's Bering Ecosystem Study (BEST) and the North Pacific Research Board's (NPRB) Bering Sea Integrated Ecosystem Research Program (BSIERP) combined to form the Bering Sea Project to study the impacts of climate change and dynamic sea-ice cover on the ecosystem of the EBS. As part of the Bering Sea Project, the Alaska Fisheries Science Center's National Marine Mammal Laboratory (NMML) collected cetacean sightings data to assess distribution, estimate abundance, and estimate trends in abundance of cetaceans, particularly fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*), on the eastern Bering Sea shelf.

Because surveys to determine distribution and abundance in the EBS are costly, NMML teamed with the Center's Resource Assessment and Conservation Engineering (RACE) division to conduct visual surveys for cetaceans during RACE's biennial echo integration-trawl survey for walleye pollock on the EBS shelf. Biologists from NMML were able to join the RACE surveys in 1997, 1999, 2000, 2002, 2004, 2008, and 2010, providing an opportunity to describe cetacean distribution and calculate abundance over a broad area of the EBS shelf. It was possible to place observers on the entire acoustic trawl survey in only 2002, 2008, and 2010; the 2008 and 2010 surveys were part of the Bering Sea Project.

Three marine mammal observers conducted visual surveys along transect lines sampled during the NOAA walleye pollock assessment survey in June and July of 2002, 2008, and 2010. Standard line-transect survey protocols were followed, with two observers using 25× (Big Eye) reticle binoculars at port and starboard stations on the flying bridge. A third observer focused on the trackline but scanned the entire area forward of the ship by eye, or with 7×50 reticle binoculars, and recorded data using the Southwest Fisheries Science Center's software program WinCruz. Effort, environmental, and species/group data were recorded for each sighting. For abundance estimation, the study area was restricted to the U.S. side of the U.S./Russia Convention Line to make the estimates comparable across years. Abundance estimates and sighting rates were computed for species with sufficient numbers of sightings, using multiple covariance distance sampling methods as implemented in the Mark-Recapture Distance Sampling (mrds) package for the statistical program R. Annual rates of change were estimated for each species by fitting an exponential growth model to the log of the abundance estimates.

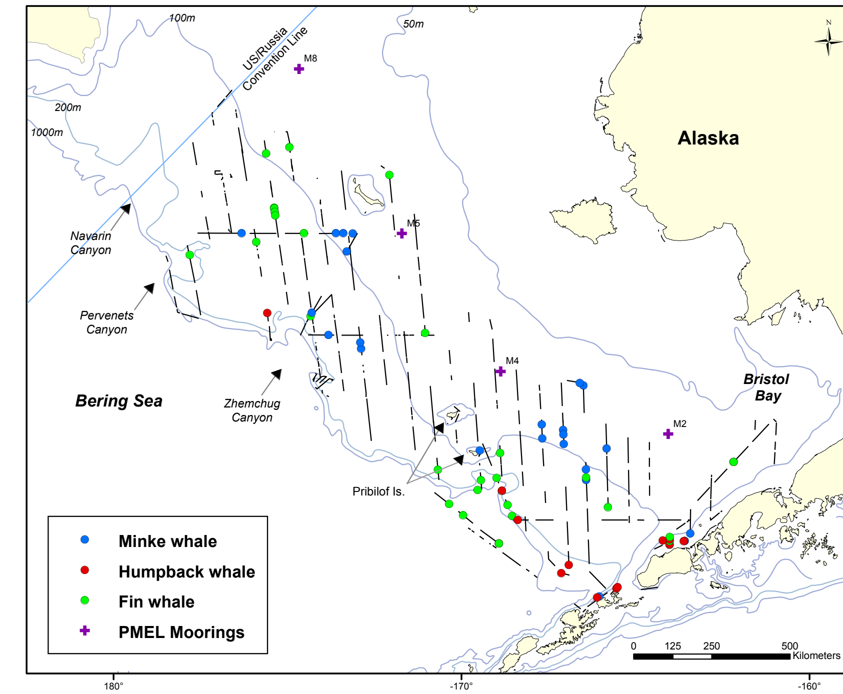


Figure 5. Sightings of mysticetes (humpback, fin, and minke whales) in 2002.

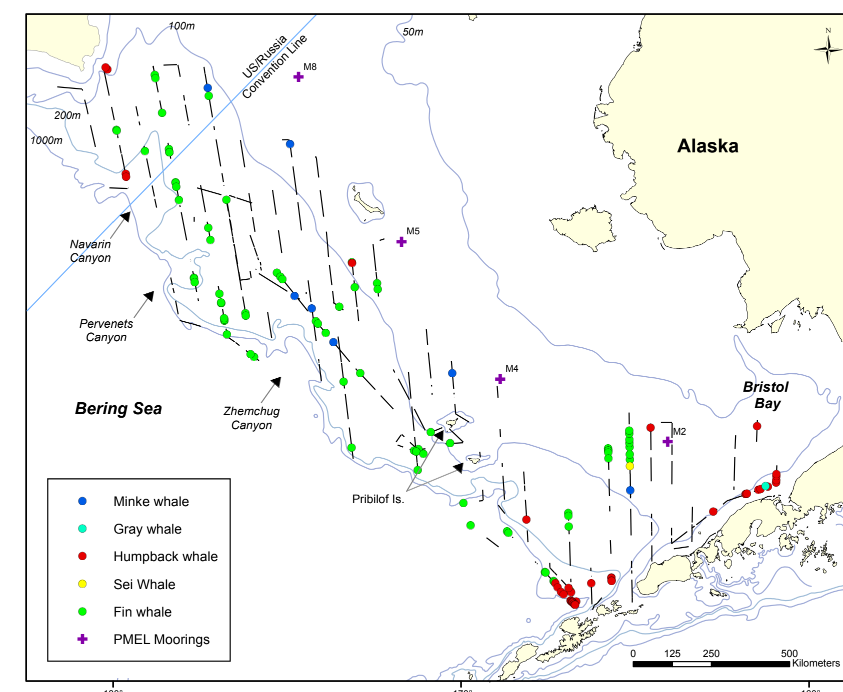


Figure 6. Sightings of mysticetes (humpback, fin, minke, gray, and sei whales) in 2008.

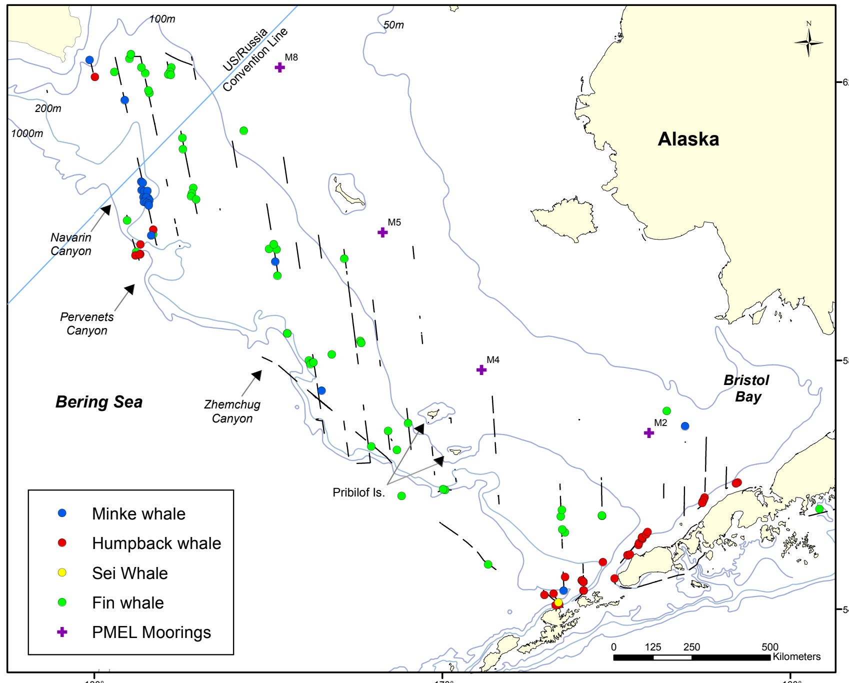


Figure 7. Sightings of mysticetes (humpback, fin, minke, and sei whales) in 2010.

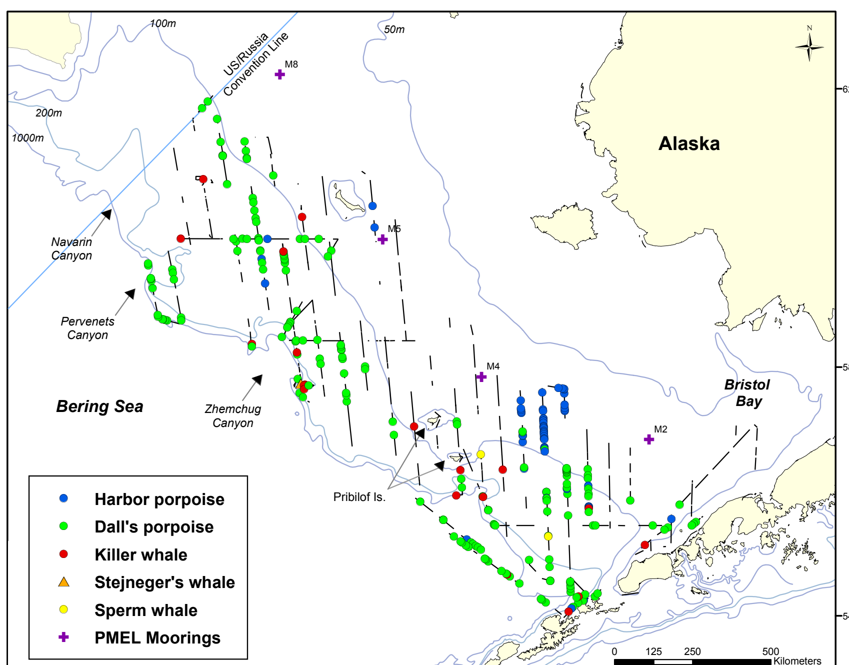


Figure 8. Sightings of odontocetes (Dall's porpoise, harbor porpoise, sperm whales, killer whales, and Stejneger's beaked whales) in 2002.

Species with a sufficient number of sightings to examine distribution and estimate abundance were humpback whales, fin whales, minke whales (*Balaenoptera acutorostrata*), Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*). Killer whales (*Orcinus orca*) were widely distributed but were not identified to ecotype ("resident," "transient," or "offshore"). Less frequent sightings included sei whales (*Balaenoptera borealis*), gray whales (*Eschrichtius robustus*), sperm whales (*Physeter macrocephalus*), Baird's beaked whales (*Berardius bairdii*), Stejneger's beaked whales (*Mesoplodon stejnegeri*), and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), as well as sightings that were not identified to species.

Distribution patterns for each species were similar among years, although differences in sampling effort confounded interannual comparisons, particularly east of the Pribilof Islands (Figs. 5-10). Humpback whales were consistently concentrated in coastal waters north of Unimak Pass and along the Alaska Peninsula, with only scattered sightings along the slope (Figs. 5-7). The vessel surveys may not have captured all of the important habitat for humpback whales. Fin whales were well distributed in the outer stratum in all years but were sparse in 2002, except for a cluster of sightings around Pribilof Canyon (Figs. 5-7). There were scattered sightings in the middle domain in all years and a cluster of sightings around 57°N, 165°W in 2008. Overall, the distribution of humpback and fin whales seemed to be consistent among all 3 years, with increased numbers of sightings of these species in 2008 and 2010 compared to 2002.

The distributions of minke whales and porpoise were more variable (Figs. 5-10). Minke whales were seen throughout the study area in all domains (Figs. 5-7). In 2002 and 2008, sightings were scattered; while in 2010, sightings were concentrated in the outer stratum in Navarin Canyon. There were roughly equal numbers of sightings in 2002 and 2010 but few in 2008. Dall's porpoise were sighted on the western edge of the middle domain and in the outer stratum in 2002; while in 2008 and 2010, all of the sightings occurred in the outer stratum (Figs. 8-10). In 2002, harbor porpoise were found in the middle domain, east of the Pribilof Islands, with scattered sightings in the outer stratum (Fig. 8). In 2008, harbor porpoise were found in the middle domain and outer stratum (Fig. 9). In 2010, there were very few harbor porpoise sightings, and they all occurred in the outer stratum, with most occurring around Pervenets and Navarin Canyons (Fig. 10).

Table 1. Estimated abundance (N), coefficient of variation (CV), and 95% confidence interval (CI) for humpback whales, fin whales, minke whales, Dall's porpoise, and harbor porpoise by year.

	2002			2008			2010		
	N	CV	95% CI	N	CV	95% CI	N	CV	95% CI
Humpback whales	231	0.63	39-1,370	436	0.45	177-1,073	672	0.80	148-3,045
Fin whales	399	0.32	210-760	1,445	0.34	738-2,831	1,155	0.38	542-2,462
Minke whales	387	0.51	146-1,030	515	0.68	146-1,818	1,936	0.73	492-7,607
Dall's porpoise	34,865	0.53	12,826-94,772	14,472	0.32	7,573-27,656	10,661	0.30	5,713-19,895
Harbor porpoise	2,031	0.46	819-5,039	3,634	0.41	1,630-8,101	728	0.66	204-2,599

A greater diversity of cetacean sightings in Navarin and Pervenets Canyons was observed in 2010 (Figs. 7, 10). Species not seen (minke whales and harbor porpoise) or rarely seen (humpback whales) in earlier years were conspicuously abundant. In addition, species commonly reported in previous years (Dall's porpoise and fin whales) were also present in large numbers. This region was also used by a humpback whale (satellite tagged by NMML personnel near Unalaska Island), which moved north across the Bering Sea shelf. The high abundance and diversity of cetaceans suggests that submarine canyons can be important habitats for cetaceans in the Bering Sea outer shelf and slope.

Abundance estimates for comparable areas in 2002, 2008, and 2010 are listed in Table 1. The estimated annual rate of change in abundance of humpback, fin, and minke whales increased between 2002 and 2010 (Table 2); the increase for fin whales is statistically significant, while the increases for humpback and minke whales are not. Given published estimated rates of increase for humpback and fin whales and what we know about the biological characteristics of humpback, fin, and minke whales, it is likely that changes in abundance in the study area are partly due to changes in distribution and not just to changes in overall population size. It is interesting to note that the Bering Sea was warmer in 2002 compared to 2008 and 2010.

In contrast, the estimated annual rate of change in abundance of Dall's and harbor porpoise decreased during this same period (Table 2); the decline for Dall's porpoise is nearly statistically significant, while the decline for harbor porpoise is not. It is unclear what could be contributing to this decrease in abundance. There was a westward shift towards deeper water in the distribution of Dall's porpoise from 2002 to 2010 and a lack of sightings of harbor porpoise in 2010, which could indicate that the important habitat for these species has shifted outside the study area. The estimates of annual incidental mortality rate are low for observed fisheries between 2007 and 2009. However, several of the gillnet fisheries that are known to interact with these stocks are not observed.

Quantitative models are being developed to integrate data on oceanographic conditions, cetacean sightings, and prey fields. These models may shed light on whether preferred habitat shifted outside the study area in warm years for mysticetes and in cold years for odontocetes. Such studies will be important for managing cetacean species, as large positive and negative deviations from the mean trend in temperature are expected in the future.

By Nancy Friday, Janice Waite, and Alex Zerbini

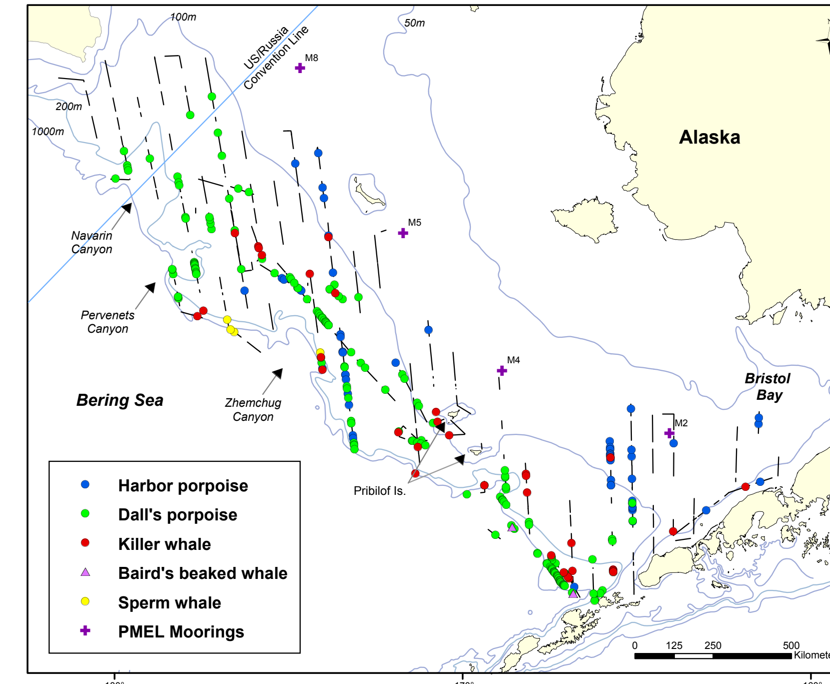


Figure 9. Sightings of odontocetes (Dall's porpoise, harbor porpoise, sperm whales, killer whales, and Baird's beaked whales) in 2008.

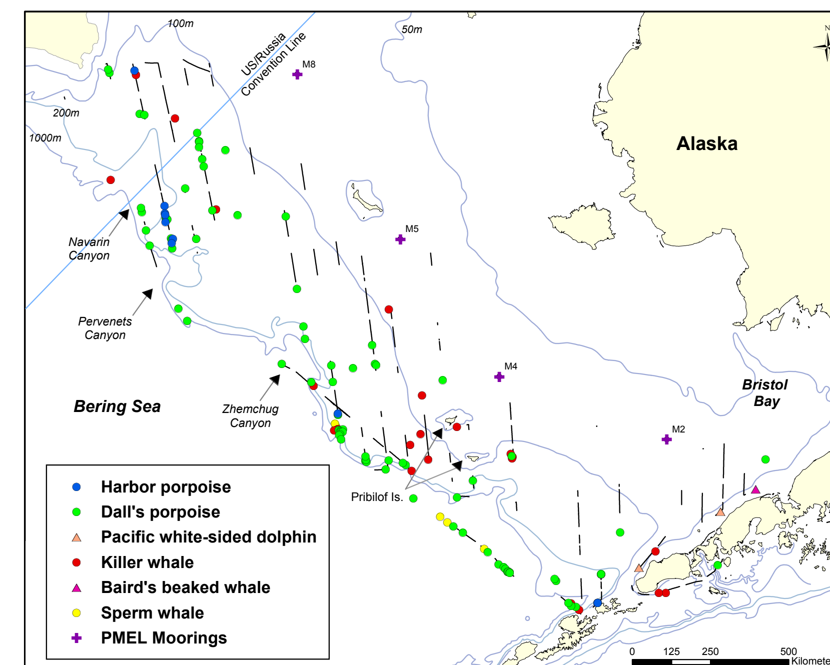
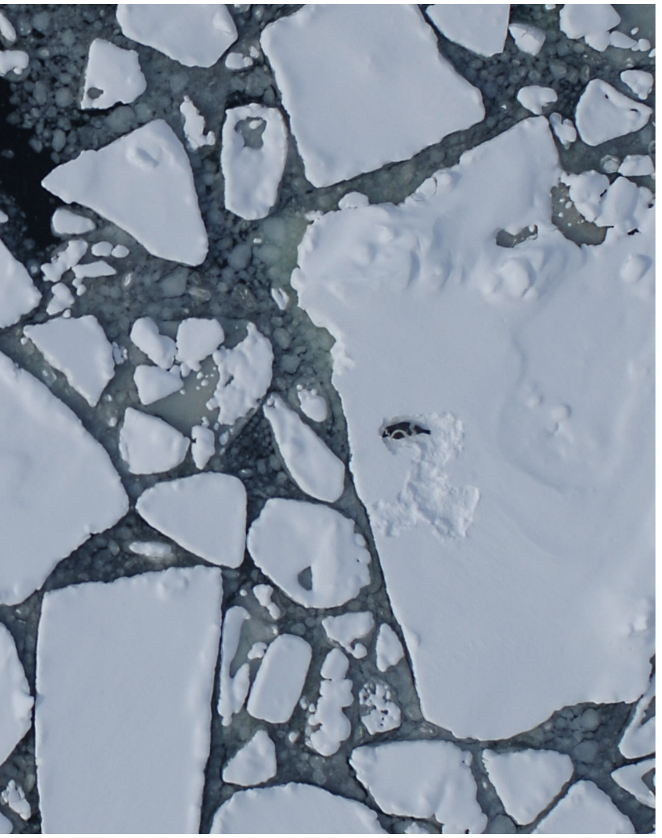


Figure 10. Sightings of odontocetes (Dall's porpoise, harbor porpoise, sperm whales, killer whales, Baird's beaked whales, and Pacific white-sided dolphins) in 2010.

Table 2. Estimated annual rate of change in abundance (r) between 2002 and 2010 and 95% confidence interval (CI) for humpback whales, fin whales, minke whales, Dall's porpoise, and harbor porpoise.

	r	95% CI
Humpback whales	12.0%	9.8 - 34.0%
Fin whales	15.8%	2.9 - 28.1%
Minke whales	15.2%	6.2 - 37.8%
Dall's porpoise	14.8%	29.7 - 0.1%
Harbor porpoise	3.4%	35.2 - 22.2%



An aerial survey photograph of an adult male ribbon seal in the Bering Sea.

Polar Ecosystems Program

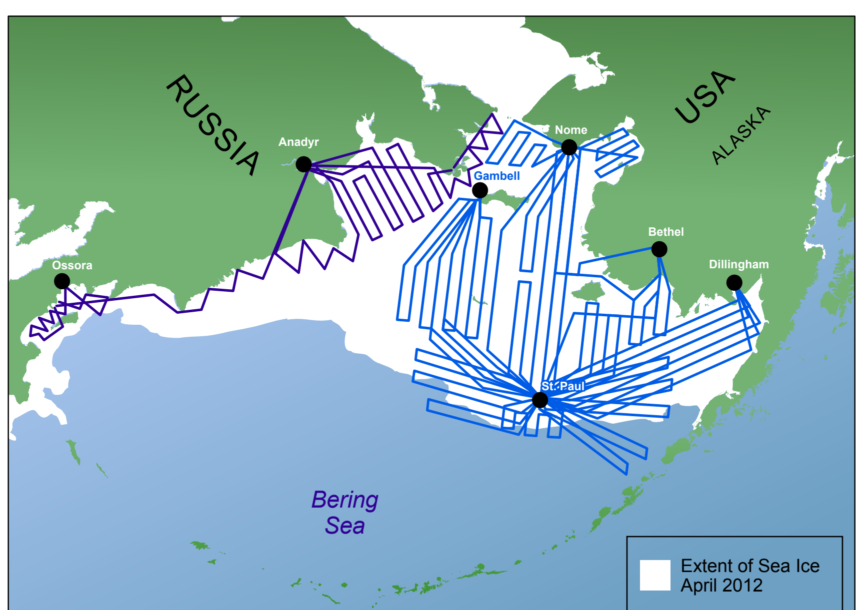
U.S. and Russia Collaborate to Study Ice Seals

Counting seals in the Bering Sea and Arctic waters is a challenging task. Four species of ice-associated seals are found in the Bering Sea: ribbon seals, spotted seals, bearded seals, and ringed seals. The Bering Sea's remote location, along with the cold and unpredictable weather, limit scientists' ability to study these animals in their natural habitat. Our knowledge about ice-associated seals populations is sparse. Figuring out how to efficiently and safely survey the region for seals has been a focus for AFSC scientists at NOAA and a multi-agency team of Russian collaborators for several years.

A U.S.-Russia team of researchers including members of the Polar Ecosystems Program has designed a large-scale, springtime aerial survey that will rely on advanced imaging systems and modern statistical techniques to provide the first comprehensive estimates of abundance for these species. Beginning in April 2012, these scientists will survey an immense area spanning the U.S and Russian sides of the Bering Sea. The planned survey will include nearly 19,000 nautical miles (nmi) of track lines over U.S. waters and 11,000 nmi over Russian waters.The survey constitutes the largest survey effort undertaken to estimate the abundance of these important seal species. The survey will last into May and a second survey is planned during the same time in 2013.

For more information visit the Polar Ecosystem Program's webpage.

By Josh London



Planned survey track lines for the United States and Russia.

Kodiak Laboratory: Shellfish Assessment Program

Ghostly Killers: Effects of Lost Fishing Gear on Red King Crab in Womens Bay, Kodiak, Alaska

Ghost fishing, which occurs when lost or abandoned fishing gear continues to trap and kill aquatic organisms, can have substantial economic and ecological effects. Lost nets can continue to ensnare animals, including birds and mammals, while lost crab or fish pots keep on attracting animals. Pots can be particularly damaging because they are often sturdily constructed and can last a long time and because animals that die inside them become bait that lures in the next set of victims. Ghost fishing gear is also non-discriminatory in that it will capture both fishery and non-fishery species, as well as individuals that would usually not be harvested, such as reproductive females.

The red king crab, *Paralithodes camtschaticus*, is an important fishery species in Alaska. There used to be a substantial commercial fishery for red king crab around Kodiak, but the stock crashed in the 1980s and has not recovered despite a fishery closure. In this study, we examined how ghost fishing affected the stock of red king crab in Womens Bay, Alaska. Womens Bay is located near the city of Kodiak and is fished for both fin fish and shellfish in commercial, subsistence, and sport fisheries. Unlike many other studies that examine lost fishing gear for trapped animals or studies that deliberately "lose" and follow fishing gear, in this study red king crabs were tracked and followed individually. This allowed us to calculate the effect on the stock as a whole rather than estimating a rate of loss per item of lost gear.

The project represents 17 years of tracking a total of 192 tagged red king crabs. Red king crabs were captured by divers in Womens Bay, tagged with acoustic tags using marine grade epoxy, and released near the site of capture. The crabs were tracked both from the surface using a surface acoustic receiver and by divers using a dive receiver. Typically, crabs were located once a week from the surface, and a sub-set of tracked crabs was dived upon. When crabs were located on the bottom, notes were made as to the behavior and disposition of the crabs. The final fate of each tagged crab also was determined. Such fates included molting, when the tag was shed along with the exoskeleton; death; or unknown. Some tags were also lost (i.e., could not be located from the surface), indicating that the tag had likely malfunctioned. When crabs died, the cause of death was ascertained if possible. Over the years, many crabs were found both alive and dead inside ghost fishing gear, primarily lost crab pots. When researchers found a ghost pot, they disabled it and released any crabs found inside. They also noted the type and condition of the pot.

Table 1. Final disposition of the 192 tagged crabs in Womens Bay tracked during this study.

Final Disposition	Number	Percent
Molted	76	39.6
Unknown	48	25.0
Lost	22	11.5
Derelict	16	8.3
Other Mortality	13	6.8
Ghost Fishing Mortality	13	6.8
Handling Mortality	3	1.6
Tag Fell Off	1	0.5

The effect of ghost fishing was calculated as a mortality rate, which was used to estimate the average annual loss of red king crabs in Womens Bay. Because some of the tagged crabs were caught in pots and released by divers, it is not known whether these crabs would have been able to escape on their own or if they would eventually have died in the pots. We therefore calculated the mortality rate twice, once assuming that all such released crabs would have escaped (a conservative estimate) and once assuming that all these crabs would have died (a maximum estimate). In addition, both the probability of being caught and the probability of being killed in ghost fishing gear were analyzed with a logistic regression to examine the effects of sex and size on ghost fishing rates.

Of the 192 crabs tagged over the course of the study, the majority molted (Table 1). Thirteen crabs were killed in ghost fishing gear, 1 in a gill net and 12 in crab pots, while another 13 died of other causes, including predation by sea otters, octopi, and humans (i.e., fishing mortality). An additional 20 crabs were caught in ghost pots and released alive by divers. Crabs were tracked for an average of 147 days. A total of 143 pots were found during the experimental period by divers. Most of

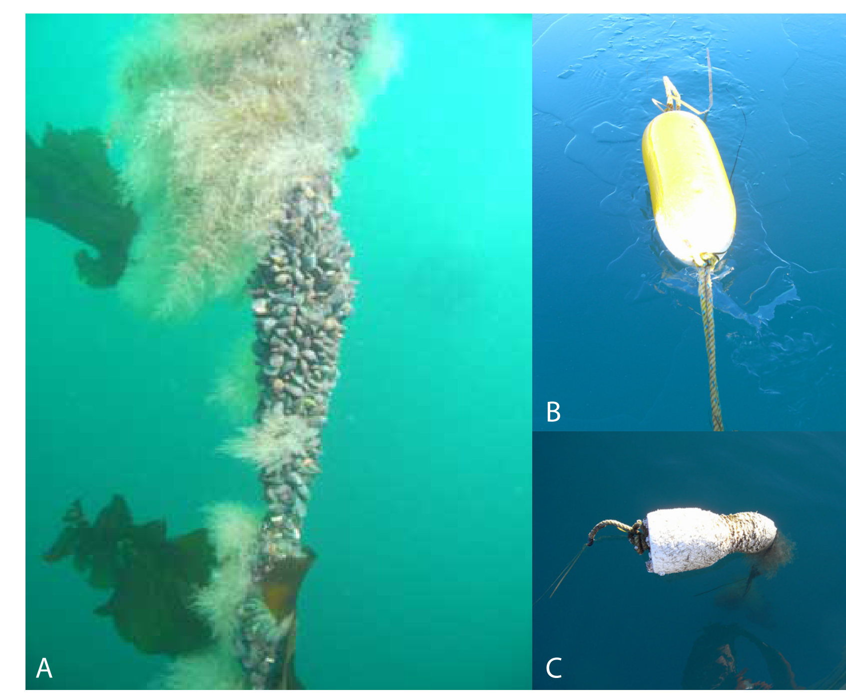


Figure 1. Some of the mechanisms of pot loss observed in Womens Bay, Kodiak, Alaska. A) Float line overgrown with marine fouling organisms that can eventually lead to the float sinking. B) Float being abraded by a thin ice sheet. C) Float after having been exposed to abrasion by ice.

Table 2. Ghost pots found in Womens Bay by divers and their disposition. Because Dungeness pots have their biodegradable release on the top, the releases will never work on upside-down pots.

Type	Number	Intact	Unknown	Upside-down	Percent intact
Dungeness	70	46	2	8	66%
Steel-frame	42	30	2	2	71%
Home made	20	10	1	2	50%
Sport pots	7	3	2	1	43%
Unknown	4	0	2	0	0%
Total	143	89	9	13	62%

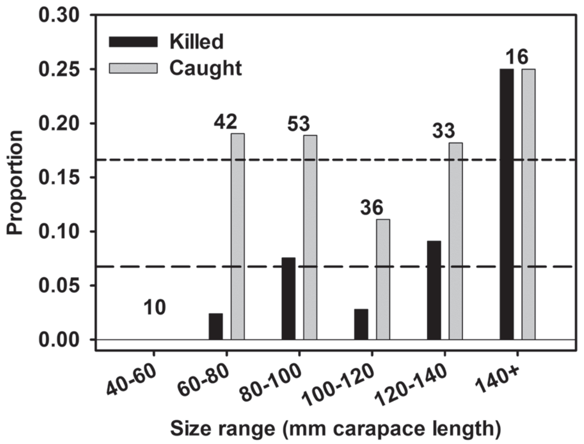


Figure 2. Proportion of tagged crabs killed (black bars) or caught (grey bars) in ghost fishing gear of total studied tagged crabs in each size class in Womens Bay, Kodiak, Alaska. Note that no crabs between 40 and 60 mm of the 10 in the study were caught or killed. The number above each set of bars represents the total number of crabs in each size category. The line with the long dash indicates the overall proportion of tagged crabs killed in ghost fishing gear, and the line with the short dash indicates the overall proportion of all crabs caught in ghost fishing gear.

these were either Dungeness crab, *Metacarcinus magister*, pots or mesh-covered steel-frame pots (Table 2). Of these pots, 62% were intact, meaning they lacked the legally required biodegradable release and were capable of ghost fishing. Likely mechanisms of pot loss include lines being cut or dragged by boats, bio-fouling of the float line, or abrasion of the float or line by ice (Fig. 1). The mortality rates calculated from the data indicate that between 16% and 37% of the red king crabs with carapace length > 60 mm in Womens Bay were killed each year by ghost fishing gear. While neither the size nor the sex of the crabs significantly affected the probability of being caught or killed in ghost fishing gear, there was a trend for larger crabs to be more vulnerable to ghost fishing (Fig. 2).

This work demonstrates that ghost fishing has a large negative effect on the red king crab stock in Womens Bay and may be an important contributor to the lack of stock recovery in the bay. Given that 60-mm crabs are vulnerable to ghost fishing and females of this size are at least 3 years from reproducing for the first time, we estimate that up to 75% of the female crabs in Womens Bay may have been killed in ghost fishing gear before successfully reproducing for the first time. This means that ghost fishing is not only reducing the population but also reducing the reproductive capacity of the population. These results suggest that efforts to remove ghost pots and to reduce the loss of pots in Womens Bay would be highly beneficial for the red king crab population.

By W. Christopher Long, Peter A. Cummiskey, J. Eric Munk

Newport Laboratory: Fisheries Behavioral Ecology

Towards an Understanding of Nursery Quality for Juvenile Tanner Crab

Bering Sea/Aleutian Island (BSAI) region Tanner crab, classified as a Tier 4 stock, are characterized by estimates of biomass, but with little habitat or ecological information guiding assessment. Tanner stocks (Gulf of Alaska and Bering Sea) are depressed or rebuilding. Stock declines are little understood but generally are attributed to over-fishing or climatic changes. Essential fish habitat knowledge for juvenile Tanner crab (age-0) is rudimentary at best. Our 2010 research examined habitat use by age-0 Tanner crabs in four Kodiak embayments; Pillar Creek Cove, Holiday Beach, Kalsin Bay, and Womens Bay (Fig. 3). Womens Bay, in particular, was chosen because it supports a Tanner crab subsistence fishery and is regarded as a crab nursery. By the end of summer 2010, age-0 Tanner crabs from Womens and Kalsin Bays were one molt stage larger than those in the Pillar and Holiday sites. Larger size at the end of the first summer could provide increased fitness to Womens Bay crabs, as they are less vulnerable to predation. Further, since Womens Bay crabs are one stage larger at summers end, they will likely reach reproductive age 1 year sooner. Understanding how nursery/habitat influences growth and size/age at maturity provides a direct linkage between essential fish habitat and crab stocks. Following on from 2010, our 2011 field work focused on several specific hypotheses addressing how these juvenile Tanner nurseries may be functioning.

Of potential causative factors contributing to the larger size of juvenile Tanner crabs from Womens and Kalsin Bays, the first factor to consider involves possible differences in the timing of recruitment; crabs may recruit earlier to Womens and Kalsin, compared to Holiday and Pillar. To examine this, we compared the May 2011 size-frequency distributions in all four embayments (Fig. 4, G = 32.57, df = 12, P = 0.001). The major difference involved Womens, where age-0 crabs (C1-C3) were nearly absent in May. Yet by mid-June, crabs appearing at Womens were already C2 or larger; one molt more than crabs at the other sites. Crabs in Kalsin were more comparable to those in Holiday and Pillar. This molt advantage attained by crabs from Womens Bay in June persisted throughout the summer, which leads us to conclude that early recruitment cannot explain the larger crabs at Womens Bay.

A second factor to consider involves potential difference in size-selective predation between embayments. Perhaps there is strong predation upon smaller crabs in Womens Bay, leading to a shifted size-frequency distribution and the "appearance" of more rapid growth. This should also be manifest by an overall larger change in population size during the post recruitment period. Recruitment was largely complete by July 2011 (Fig. 4) and, therefore, population changes

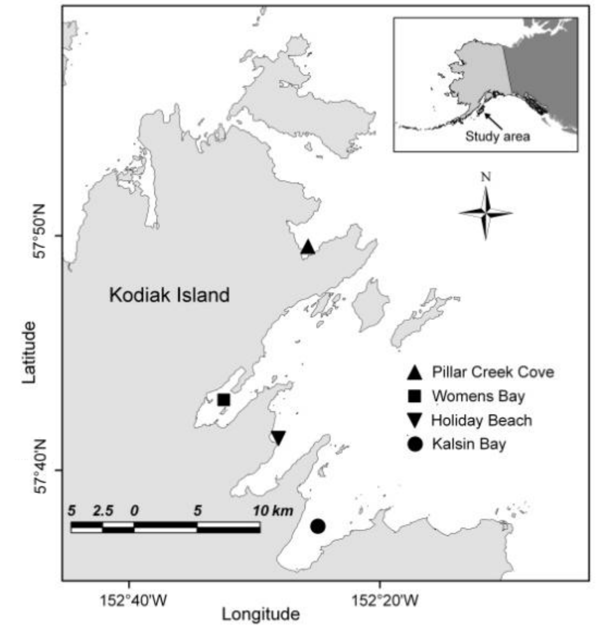


Figure 3. Location of study sites.

from July to August were due to mortality or emigration/immigration. Neither Womens nor Kalsin Bays experienced significant population declines from July to August (Fig.5, Womens: Wilcoxon, P = 0.413, Kalsin: P = 0.204). At Pillar, crab abundances declined significantly (Wilcoxon U, P = 0.040). The decline at Holiday was not significant (Wilcoxon, P = 0.419). Crabs were surviving and remaining resident at Womens and Kalsin Bays, and to a lesser extent at Holiday, but dying and/or emigrating at Pillar. Therefore, we can reject the size-selective predation hypothesis as an explanation for larger crabs at Womens Bay.

It may be that crabs are indeed growing faster at Womens Bay. Water temperature is often a critical factor influencing the growth of juvenile crabs and fishes. Therefore, we conducted a laboratory experiment to examine temperature dependence of growth in juvenile Tanner crabs. Higher temperature significantly accelerated Tanner growth in the lab (Fig. 6). The C2-C3 intermolt period was 46 days at 6°C but only 30 days at 9°C. Similarly, the C3-C4 intermolt period was 56 days at 6°C but 43 days at 9°C. Yet temperature loggers at each site (~15m) during 2001 indicated only minor temperature differences. During the early summer, when crabs at Womens Bay appeared to undergo accelerated growth, the average difference in temperature between sites was only 0.3°C. Therefore, we consider it unlikely that temperature, at the depths we studied, was a significant contributor to the differential growth between populations.

A final factor we considered involved food quality. More specifically, we hypothesized that food quality may be better at Womens Bay, leading to more rapid growth. We reasoned that this should be reflected in the condition and tissues of crabs from the different embayments. In 2011, crabs were collected for extraction and analysis of storage lipids and fatty acid biomarkers. Unfortunately, these samples were lost in a freezer malfunction (word to the wise, check alarm systems). However, samples taken at Womens, Pillar, and Holiday during July 2010 suggest a possible difference in diet between sites. Significant differences occurred in the amount of storage lipid in crabs from the three coves. Pillar crabs had significantly lower storage lipid (triacylglyercols, ~8%) compared to Holiday and Womens (~20%). Womens crabs had consistently higher levels of fresh diatom fatty acid biomarkers than crabs from the other embayments. More specifically, the levels of 20:5n-3 was significantly higher in crabs from Womens. This specific essential fatty acid has previously been demonstrated to accelerate growth in larval Pacific cod, larval rock sole, and wild red king crab juveniles. Not only was this essential fatty acid and diatom marker found at higher levels in Womens Bay crabs, it was strongly correlated with the carapace widths of juvenile C3 crabs across the three bays (Fig. 7, $r^2 = 0.60$). While we hope future samples will further clarify this mechanism, these data support the food quality hypothesis.

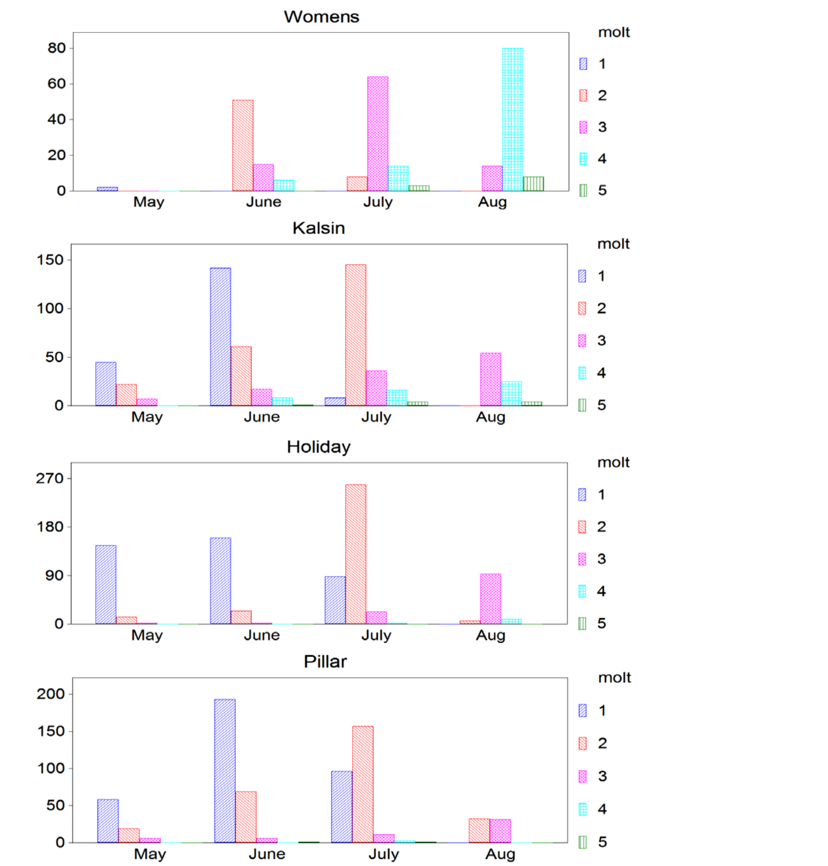


Figure 4. Relative size frequency distributions of age-0 yr Tanners from each site, May – August.

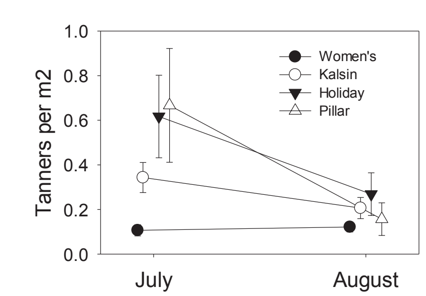


Figure 5. July to August population size changes at each site.

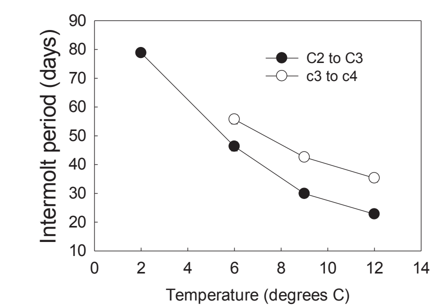


Figure 6. Influence of temperature on C2-C3 and C3-C4 inter-molt periods.

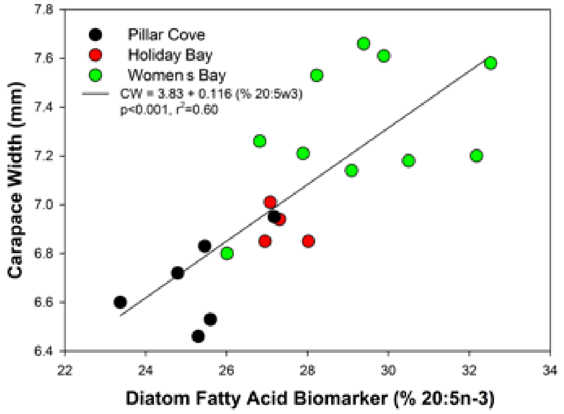


Figure 7. Relationship between diatom dietary marker and carapace width of C3 crabs from 3 Kodiak nursery embayments.

To date, our work has shown that juvenile Tanner crabs rearing in Womens Bay achieve a size advantage over juveniles rearing in other nearby embayments. Further, our data suggest this is a result of differential growth; more specifically, that there is better quality of food in Womens Bay. This size advantage may enhance crab survival as they move out of nurseries and into deeper water, where predation may be more intense. Further, more rapid growth will likely translate into earlier entry into the reproductive population and commercial population. In 2012 we will test additional hypotheses related to juvenile Tanner crab growth in Kodiak nursery embayments, with the goal of eventually expanding this work to the greater Gulf of Alaska and the Bering Sea. First we will examine the dietary issue. We suspect that the lower wave energy in Womens Bay may allow for greater retention of organic material in the form of a sediment surface "fluff" layer or benthic diatoms, which provide a superior food source for juvenile crabs. We will sample the newly settled organic material or fluff layer in Womens Bay and Pillar Creek Cove during July 2012 and analyze the material for total organic matter per dry weight, lipid classes, and fatty acid biomarkers. Crabs will also be sampled from each site and analyzed for lipids, fatty acid biomarker, and δ13C and δ15N analyses. These approaches will clarify differences in sources of organic material and elucidate whether crabs are feeding at different trophic levels in Womens and Pillar embayments. This will be accompanied by laboratory experiments, examining the effects of lipid profiles upon Tanner crab growth. Gel food diets will be formulated to mimic the differences that we have observed in essential fatty acids in the field. At the end of the experiment, in addition to quantifying crab growth, we will assess the effect of variable diet on the lipid condition of crabs. This data will be merged with our temperature growth data to develop a predictive model of juvenile Tanner growth as a function of dietary quality and temperature. Lastly, we will examine whether there is an alternative shallow water habitat (<5m) that may be accessible to settling Tanner crabs during May in Womens Bay, with periodic temperature stratification (low wave action = greater potential for warm shallows) giving crabs a temperature growth bump. These approaches should provide us with a more thorough understanding of how habitat characteristics determine nursery quality, and in turn, the function of these nurseries in supporting Tanner crab populations.

By Clifford Ryer and Louise Copeman
(CIMRS, Oregon State University)

Groundfish Assessment Program /
Habitat Research Group

Improved Long-Range Sonar Delivered and Tested

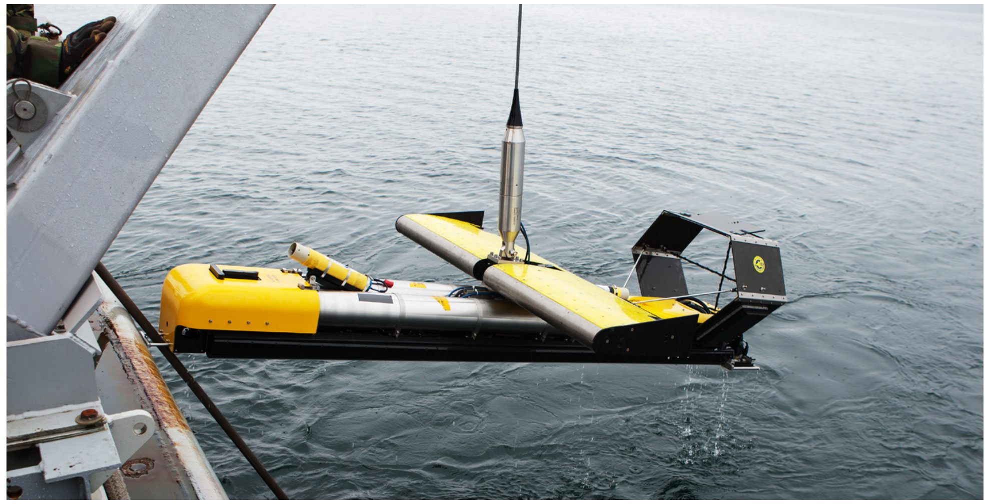
Scientists in the Habitat Research Group (HRG) are conducting studies to identify the essential habitats of eastern Bering Sea species. This includes work to identify suitable predictor variables for quantitative habitat models and to develop tools to map these variables over very large areas.

Abundance estimates from annual bottom trawl surveys are being combined with synoptic environmental data to produce basin-scale continuous-value habitat models that are objective and have quantifiable uncertainty. The resulting quantitative relationships not only satisfy the Congressional mandate to identify and describe essential fish habitat (EFH), they may also be used to gauge the effects of fishing-gear disturbances, to enhance fish-stock assessments, and to predict the redistribution of species as a result of environmental change.

The broad geographic scope of EFH studies requires a very efficient process for acquiring high-quality environmental data. Previous research by the HRG indicates that seafloor sediments affect the distribution and abundance of eastern Bering Sea groundfish but also reveals that synoptic sampling with bottom grabs is impractical. Subsequent research has shown that acoustic characterization of the seafloor provides useful data for our habitat models, but conventional sonars may still require an inordinate amount of time to sample large areas.

The Klein 7180 long-range side scan sonar (LRSSS) is new technology that was purpose-built for our fish-habitat research. It is distinguished from all other sonar systems by its ability to collect fully adjusted quantitative information about seafloor characteristics and is thus ideally suited for modeling applications. The very large swath coverage (to 1.0 km) and high maximum tow speed (12 kts) of the LRSSS greatly increase the efficiency of survey operations, thereby reducing costs and the time required to complete missions. The broad swath coverage of the integrated bathymetric subsystem may also improve the efficiency of hydrographic reconnaissance in the Arctic and could be a safer alternative to launch-based surveying in nearshore areas.

Scientists Lloyd Huff, Peter Runciman, and Steve Intelmann (left to right) carefully monitor seafloor habitat data streaming from the LRSSS while it is being towed in Port Madison, Puget Sound. Photo by Karna McKinney



The Klein 7180 long-range side scan sonar (LRSSS) being deployed for testing from the U.S. Navy vessel Battle Point YTT-10. Photo by Karna McKinney

One of the two LRSSS systems used by the HRG was recently upgraded to improve performance and the quality of data produced for EFH characterization and mapping. Most importantly, the system now provides calibrated backscatter across the entire survey area. This is accomplished with an innovative "cascade calibration" that uses overlapping swaths of data to transfer the calibrated backscatter from a simple downward-looking sonar (altimeter) to the other acoustic subsystems covering the nadir (under the towfish) and the outlying side-scan regions. This Mills-cross type altimeter is easily removed for tank calibration and can then be readily reinstalled in a fixed position as needed for periodic recalibration of the LRSSS system. Bathymetric data from the LRSSS are used to produce a digital elevation model that is the basis for one form of backscatter correction. The improved LRSSS now acquires these data using the process of interferometry as opposed to a more complex solution based on an integrated multibeam echosounder. Both the original and improved systems also acquire calibrated 38-kHz single-beam backscatter and basic water-quality measurements (chlorophyll-a, concentrations of dissolved organic matter, and turbidity) while acquiring the primary backscatter (180 kHz) and bathymetry data. These ancillary data are being investigated for use in the next generation of our eastern Bering Sea habitat models.

The improved LRSSS was tested 24-30 March during sea trials conducted in Port Madison, Puget Sound, Washington, on the U.S. Navy vessel USNV Battle Point YTT-10. During the sea trials, performance expectations were confirmed, system characteristics such as pitch, roll, and yaw offsets were measured, and operator training was provided by a system engineer with the LRSSS manufacturer. Groundtruthing devices that the HRG use to interpret acoustic backscatter were also exercised as part of the preparations for a major Bering Sea cruise this summer on the NOAA ship *Fairweather*. This project will compare the cost-benefits of the LRSSS with more conventional sonars, including two hull-mounted hydrographic-quality multibeam echosounders and another high-resolution side scan sonar system. Although primarily a scientific experiment, the FISHPAC project will also provide hydrographic-quality bathymetric data to the NOAA Pacific Hydrographic Branch for updating nautical charts in areas with outdated or non-existent information. Strategic partnering is an important element of this Integrated Ocean and Coastal Mapping project involving three branches of NOAA (National Marine Fisheries Serivce, Office of Marine and Aviation Operations, and National Ocean Service), with significant technical support provided by the Naval Undersea Warfare Center Division Keyport, L-3 Communications Klein Associates, and Dr. Lloyd Huff, a private consultant to the HRG and design authority for the improved LRSSS.

By Bob McConnaughey

RACE
DIVISION/
LABORATORY
REPORTS

NOAA Corps Hydrographer Joins the Habitat Research Group

Adam Pfundt. Photo by Karna McKinney

In 1996, Congress recognized the need for basic information about the habitats used by fish and shellfish and mandated the National Marine Fisheries Service (NMFS) to describe and identify essential fish habitat (EFH) of all federally managed species in the U.S. Exclusive Economic Zone. The National Ocean Service (NOS) is responsible for hydrographic surveys and nautical charting to ensure safe, efficient, and environmentally sound marine transportation in these same waters. Both mandates require quantitative environmental observations of the seafloor over sizable geographic areas. As such, there is a great opportunity for collaborative efforts to develop a seafloor map for multiple purposes. This is the theme of NOAA's Integrated Ocean and Coastal Mapping initiative.

Recognizing the potential benefits of collaborations between biologists and hydrographers, a unique "cross-over" billet was established to encourage productive interactions between the Alaska Fisheries Science Center and the Pacific Hydrographic Branch, which are both located at NOAA's western regional campus in Seattle. Beginning in 2005, a NOAA Corps hydrographer has been billeted with the RACE Division's Habitat Research Group (HRG) as a benthic mapping specialist. This officer is required to have extensive experience acquiring and processing hydrographic data and to have an interest in fisheries-related studies. He/she primarily functions as a liaison between NOAA's hydrographic community and HRG scientists. Previous duties have included participation in multi-mission cruises to collect acoustic backscatter for use in quantitative fish-habitat models; preparation of hydrographic data to update nautical charts, including a first-ever comprehensive survey of Pribilof Canyon; and the development of specialized technology for acquiring and processing multi-purpose environmental data.

ENS Adam Pfundt joined the HRG on 18 January 2012 to begin a 3-year assignment as a benthic mapping specialist. He replaces LT Meghan McGovern who has returned to sea duty in Alaska. Adam served one field tour as a hydrographer aboard the NOAA ship *Fairweather* working in the Bering Sea and the Arctic. He holds a bachelor's degree in fisheries science from the University of Washington, has worked as a fisheries biologist, and has extensive commercial fishing experience in Alaska and Washington. He is very well-suited to his new position and will participate in the multi-mission FISHPAC research cruise this summer in the eastern Bering Sea. Welcome Adam!

Bob McConnaughey

Wormy Habitat Too Cold for Worm-eaters?

Yellowfin sole, northern rock sole, and Alaska plaice are three common flatfish that co-occur in the southern eastern Bering Sea (EBS) shelf at depths usually not exceeding 100 m. Their small mouths are adept at preying on infauna, especially polychaete worms. The average diet of Alaska plaice consists of almost 60% polychaetes by weight. For yellowfin sole, which has the most varied diet of the three species, polychaetes still comprise over a quarter of their diet by weight. An essential fish habitat (EFH) study in 2009 provided insights on the relationships between flatfish habitats, diets, and prey availability. Benthic grab samples and flatfish stomachs were collected at 31 RACE bottom-trawl survey stations across the shelf (Fig. 8). The two data sets were analyzed for correspondence between stomach contents and infauna assemblages across habitat types.

Polychaetes and clams were the most dominant groups, each comprising 35%-60% by weight of each infauna sample. They were also the only prey groups that frequently averaged over 50% of stomach content weight. Sediment grain size was the most important factor in determining the type of infauna assemblage in the habitat (Fig. 9). Grain size becomes smaller, i.e. sediment becomes muddier, the further from shore (or deeper the water). Clams dominated the infauna biomass on the sandy inner shelf (0-50 m depth) (Fig. 9). The "muddy sand" of the middle shelf (50-100 m) had the highest infauna biomass, which was dominated by deposit-feeding polychaetes.

Prey availability strongly influenced diet choices. Stomach contents of all three flatfish generally reflected the infauna assemblage of the habitat where they were collected (Fig. 9). Alaska plaice clearly adapted to prey availability – they ate mostly clams on the inner shelf, although their primary prey are polychaetes. All flatfish switched to eating more polychaetes on the middle shelf, even yellowfin sole, whose primary prey are amphipods and clams.

Polychaetes may not be obligatory prey for these flatfish, but they could very well be the choice prey, considering that polychaetes are overall the most dominant infauna group in the EBS and generally have a higher organic nutrient content than the other major groups: clams, amphipods, and brittlestars. Under this hypothesis, the biomass or abundance of polychaetes could indicate the quality of the habitat for flatfish in terms of prey availability. Alaska plaice, northern rock sole, and yellowfin sole obviously all eat polychaetes. Their actual proportion intake of polychaetes may be a result of interspecific competition.

The middle shelf domain supports high infauna biomass because of high benthic productivity shaped mainly by hydrography. The nutrient environment and sediment type there particularly favor deposit-feeding polychaetes. This polychaete-rich habitat would presumably be highly suitable to flatfish, especially Alaska plaice. However, in 2009, bottom-trawl survey results showed that Alaska plaice were concentrated on the inner shelf (Fig. 10), like northern rock sole and yellowfin sole.

The year 2009 was one of the coldest years in the recent decade in the Bering Sea. That summer, an intense "cold pool" of <2 °C bottom water from the spring ice melt extended far south over the middle shelf (Fig. 10). This physiological barrier may have kept flatfish from the middle shelf, depriving them of quality polychaete prey and intensifying competition for prey on the inner shelf. When the cold pool is not as well-developed, interspecific competition among the flatfish may be mitigated by slightly-offset spatial distributions to utilize different infauna assemblages across the shelf.

By Cynthia Yeung

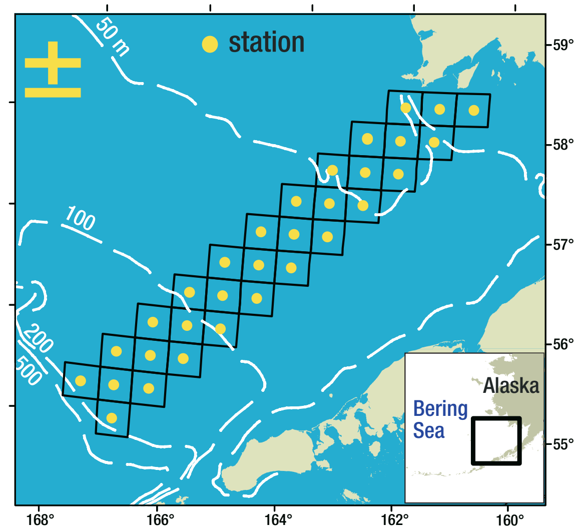


Figure 8. Study area and sample station locations within RACE bottom-trawl survey grid cells.

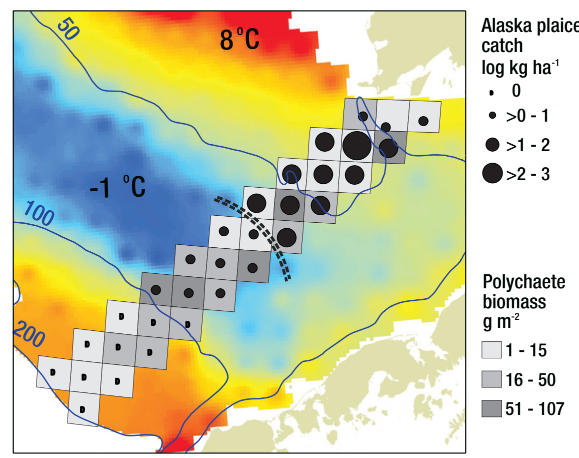


Figure 9. Percentage composition of the four major infauna groups in the benthos ("Infauna") and in the stomachs of each flatfish species ("Diet") at each station. In the "Infauna" plot, the sediment type (in percentage of mud the sediment sample contains; sand % = 100 - mud %) of each station cell is also depicted. In the "Diet" plots, empty cells indicate no stomachs were collected.

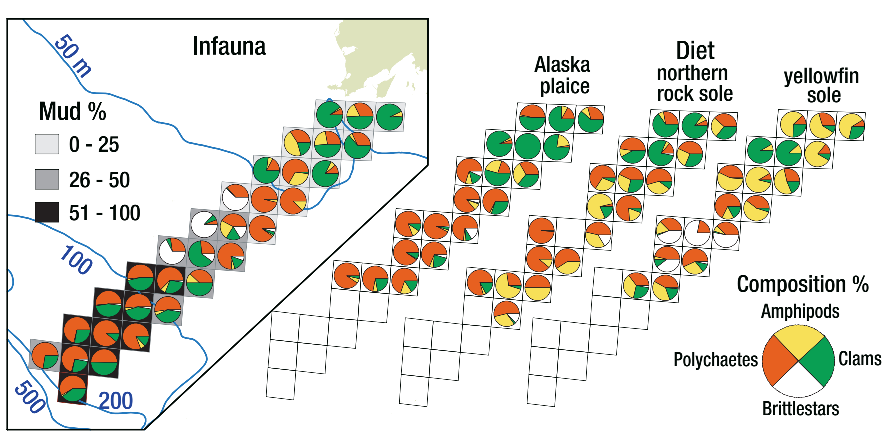


Figure 10. The distributions of Alaska plaice catches and polychaete biomass at stations surveyed across the EBS shelf in this study, superimposed over the colormap of bottom water temperature in summer 2009. The temperature ranged from -1°C (blue) to 8°C (red). The 50, 100, and 200 m isobaths are delineated. Double dotted curve (black) approximates the inshore edge of the "cold pool" of <2°C bottom water. Highest concentration of Alaska plaice lies inshore of the cold pool, whereas highest polychaete biomass is mostly within the cold pool.

The Alaska Coral and Sponge Initiative (AKCSI): a NOAA Deep-Sea Coral Research and Technology Program regional fieldwork initiative in Alaska

Staff from the AFSC's Groundfish Assessment Program and their collaborators will begin a 3-year study this summer of deep-sea corals and sponge ecosystems in Alaskan marine waters. Alaska's regions, such as the western Aleutian Islands, may contain the most diverse and abundant deep-sea coral and sponge communities in the world. These communities are associated with important groundfish and invertebrate species. Because of their biology, corals and sponges are potentially impacted by climate change and ocean acidification; they also are vulnerable to the effects of commercial fishing activities. The challenges facing management of deep-sea coral and sponge in Alaska begin with the lack of knowledge of where these organisms occur, their abundance and diversity. Because of the size and scope of Alaska's continental shelf and slope, the vast majority of the area has not been surveyed for deep-sea coral and sponge abundance; therefore, it is difficult to predict how and where human activities and climate impacts may affect deep-sea coral and sponge ecosystems.

NOAA's Deep-Sea Coral Research and Technology Program (DSCRTP) will fund research in Alaska to examine the location, distribution, ecosystem role, and status of deep-sea coral and sponge habitats based upon regional research priorities identified by the DSCRTP, the North Pacific Fishery Management Council and the Essential Fish Habitat-Environmental Impact Statement (EFH-EIS) process.

Research priorities include:

- Determine the distribution, abundance, and diversity of sponge and deep-sea coral in Alaska (and their distribution relative to fishing activity);
- Compile and interpret habitat and substrate maps for the Alaska region;
- Determine deep-sea coral and sponge associations with species regulated by fishery management plans (especially juveniles) and the contribution of deep-sea coral and sponge ecosystems to fisheries production;
- Determine impacts of fishing by gear type and test gear modifications to reduce impacts;
- Determine recovery rates of deep-sea coral and sponge communities in Alaska from disturbance or mortality; and
- Establish a long-term monitoring program to determine the impacts of climate change and ocean acidification on deep-coral and sponge ecosystems.

To date, field research activities scheduled for 2012-14 for the Alaska region involve the Alaska Fisheries Science Center, the NMFS Alaska Regional Office, National Centers for Coastal Ocean Science, Office of Exploration and Research, and the University of Alaska, Fairbanks. Projects include

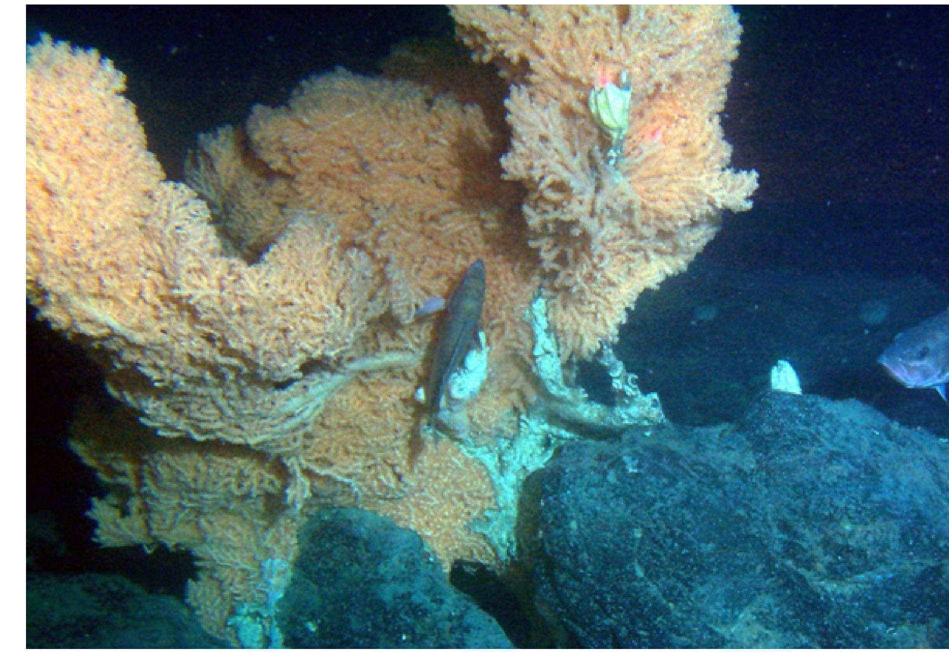


Figure 11. Rockfish species with Primnoa pacifica within a rocky coral habitat in Southeast Alaska. Photo courtesy of Bob Stone.

- Identifying and mapping areas of high abundance of Primnoa corals (Fig. 11) in the Gulf of Alaska using existing data, conducting new multibeam mapping and ROV transects;
- Developing a model to predict the distribution and areas of high abundance and diversity of deep-sea corals and sponges in the Gulf of Alaska and Aleutian Islands;
- Verifying the model through field sampling using underwater cameras;
- Estimating the recovery rates and sustainable impact rate for Primnoa corals in the Gulf of Alaska through a landscape ecology approach; and
- Determining how the presence and absence of corals and sponges affects the productivity of fish.
- Incorporating an underwater camera system to examine the effects of commercial long-line fishing on benthic habitats in the Gulf of Alaska;
- Using genetic techniques to explore the connectivity of Primnoa populations among the Gulf of Alaska, British Columbia, and the west coast of the United States; and
- Deploying oxygen and pH sensors on AFSC summer bottom trawl surveys.
- A number of smaller scale projects will be funded as well.

At the conclusion of this 3-year field effort we will advance the knowledge of the Alaskan deep-sea corals and sponges and improve the management of these resources using the most up-to-date scientific information and understanding of human and climate impacts. We will produce distribution maps for important areas with deep-sea corals and sponges, describe the growth of select deep-sea coral species, and understand how deep-sea coral and sponge communities influence the productivity of important fish and invertebrate species. Stay tuned for project updates!

By Chris Rooper and Wayne Palsson

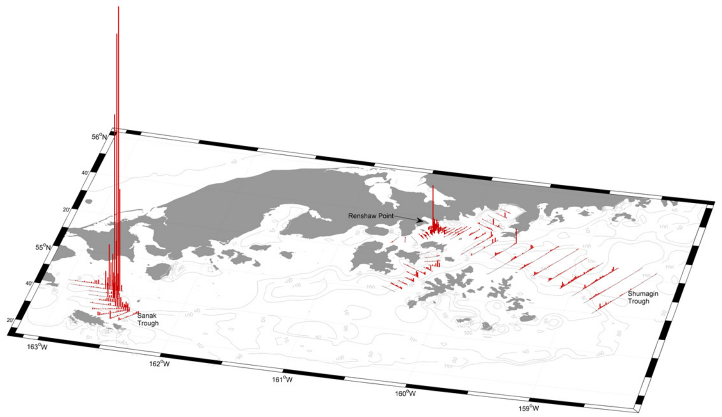


Figure 12. Acoustic backscattering (sA) attributed to walleye pollock (vertical lines) along transects during the February 2012 acoustic-trawl surveys of the Shumagin Islands and Sanak Trough in the Gulf of Alaska. The largest value shown in this figure represents 36,700 SA.

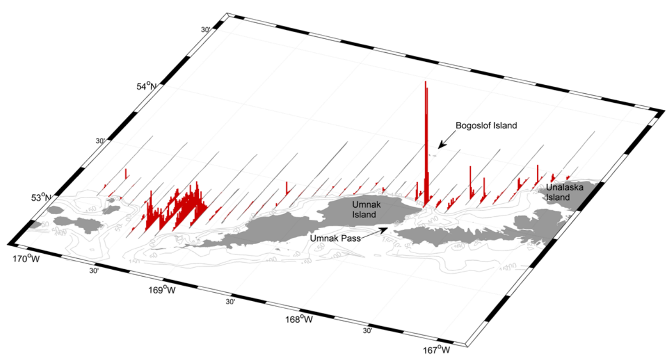


Figure 13. Acoustic backscatter (sA) attributed to walleye pollock (vertical lines) along tracklines during the March 2012 acoustic-trawl survey of walleye pollock in the southeast Aleutian Basin near Bogoslof Island. The largest value shown in this figure represents 19,300 SA.

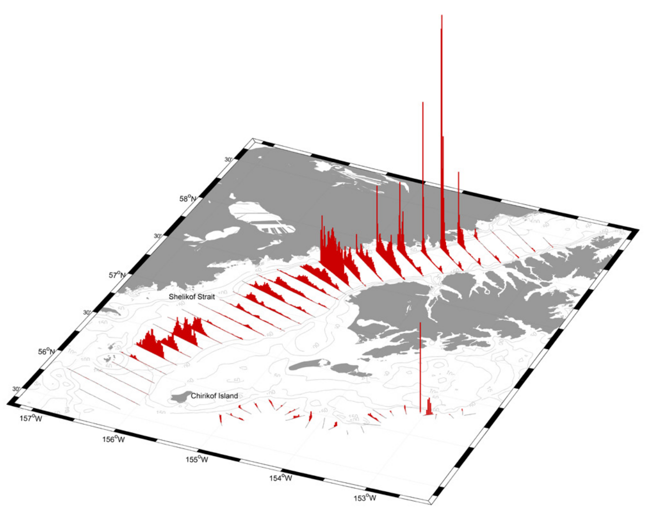


Figure 14. Acoustic backscattering (sA) attributed to walleye pollock (vertical lines) along transects during the March 2012 acoustic-trawl surveys of Shelikof Strait and along the Gulf of Alaska shelfbreak from Barnabas Trough to Chirikof Island. The largest value shown in this figure represents 51,500 SA.

Midwater Assessment & Conservation Engineering (MACE) Program

Winter Walleye Pollock Surveys in the Gulf Of Alaska and the Southeastern Bering Sea Near Bogoslof Island

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program conducted winter acoustic-trawl surveys aboard the NOAA ship *Oscar Dyson* in the Gulf of Alaska (GOA) and southeastern Bering Sea. The surveys provide data on the abundance, distribution, and biological composition of prespawning walleye pollock, *Theragra chalcogramma*. Areas surveyed between 15 and 20 February 2012 included Sanak Trough and the Shumagin Islands (Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait). The area in the vicinity of Bogoslof Island in the southeastern Bering Sea was surveyed between 7 and 15 March. Areas surveyed between 17 and 26 March were the shelfbreak east of Chirikof Island and the Shelikof Strait area. All surveys were conducted 24 hours per day.

In Sanak Trough, preliminary survey results indicated that the 2012 biomass estimate was similar to recent surveys (2008-10). Most walleye pollock were located in the northern part of the survey area within the trough proper (Fig. 12), and the size composition was unimodal, with most fish between 40 and 70 cm FL. Unlike all previous surveys, which had high percentages of spawning and spent females, the 2012 survey reflected lower percentages although survey timing was similar to previous years. The preliminary 2012 walleye pollock abundance in the Shumagin Islands area was the lowest in survey history and was less than one-quarter of the 2007 estimate, which was a 5-year high. Light near-bottom adult walleye pollock densities were detected off Renshaw Point (Fig. 12), where until 2007 the highest quantities of adults had historically been detected. Light on-bottom echosign was detected in Shumagin Trough. Very little echosign attributed to walleye pollock was detected elsewhere in the Shumagin Islands. The length distribution of walleye pollock in the Shumagin Islands area consisted primarily of adult fish between 40 and 70 cm fork length.

The preliminary walleye pollock abundance estimate in the southeastern Aleutian Basin near Bogoslof Island was the lowest in survey history. Pollock were observed northeast of Umnak Island and in the Samalga Pass region with the densest aggregations off Umnak (Fig. 13). The size composition ranged from 41 to 68 cm FL, with a dominant mode centered at 50 cm in the Umnak Island region and 60 cm in the Samalga Pass region. Preliminary analysis of maturity stages indicated that the majority of female pollock were prespawning in both the Samalga and Umnak regions, indicating that the survey timing was consistent with historical efforts.

The preliminary walleye pollock biomass estimate in Shelikof Strait was about 75% of the 2010 estimate but higher than those of 2006-09, and, as in 2010, the highest fish densities were observed along the west side of the strait proper between Cape Kekurnoi and Cape Kuliak (Fig. 14). Densities were relatively light on the Kodiak side of the strait and south of the strait proper. Most pollock catches consisted of a mixture of age-2 and older adult fish, with older fish dominating in the deepest part of the strait and the reverse true elsewhere. The 2012 pollock biomass estimate along the GOA shelf break in the vicinity of Chirikof Island was the highest observed since 2008. As is typical for this survey, only adult fish were observed. Preliminary analysis of maturity stages revealed that the majority of female pollock were prespawning in both the Shelikof Strait and along the Chirikof shelf break, indicating that the survey timing was consistent with historical efforts.

By Michael Guttormsen and Denise McKelvey

Resource Ecology & Ecosystem Modeling Program

Multispecies Stock-Assessment (MSM) and Bioenergetic Modeling

Multispecies Stock Assessment Modeling (MSM) is a three-species model of some of the most productive stocks and key predators in the Bering Sea – walleye pollock, Pacific cod, and arrowtooth flounder. Their biological interactions may influence natural mortality estimates and subsequent harvest recommendations. Thus, MSM is a logical tool for implementing ecosystem-based management of fisheries resources in the Bering Sea. MSM combines traditional catch-at-age stock assessment models with multispecies virtual population analysis models (MSVPA) in a statistical framework and uses abundance and diet data to estimate fishing mortality, recruitment, stock size, and predation mortality. MSM typically models the latter as a series of functional bioenergetics responses to derive temperature-dependent predator rations. Since MSM can capture critical threshold effects that characterize many ecological interactions, such an approach also provides a statistical framework to evaluate and manage both the direct and indirect effects of fisheries harvest on multiple species. Additionally, we used projections of the model to derive biological reference points (BRPs) for various harvest control rule approaches under variable climatic conditions. In particular, we have generated projections for the three species under various target harvest rates including 1) no fishing and 2) fishing to 40% of the unfished spawning biomass. Model predictions were compared to single species assessments from 2011 as well as Ecosim predictions for the Bering Sea (Fig. 1). We are currently synthesizing results for publication.

As part of the MSM modeling effort we have also been conducting comparative analyses of annual predator rations estimated from 1) digestive corrections applied to the data, 2) von Bertalanffy derived estimates of consumption, and 3) estimates from Wisconsin bioenergetic models for the three species (Fig. 2). Various ration estimates are compared to data from the food habits database and provide indices of predation pressure over time. These results are part of a manuscript currently in preparation.

By Kirstin Holsman

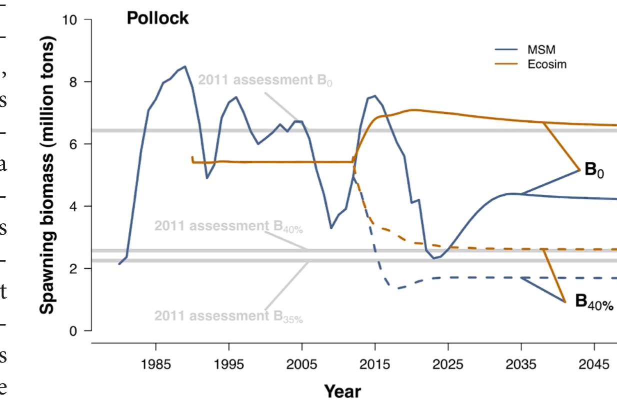


Figure 1. MSM estimates of spawning biomass of walleye pollock from the Eastern Bering sea (blue line) and projections of unfished and 40% unfished biomass from MSM (solid and dashed blue lines, respectively), Ecosim (orange lines), and the 2011 stock assessment (horizontal gray bar).

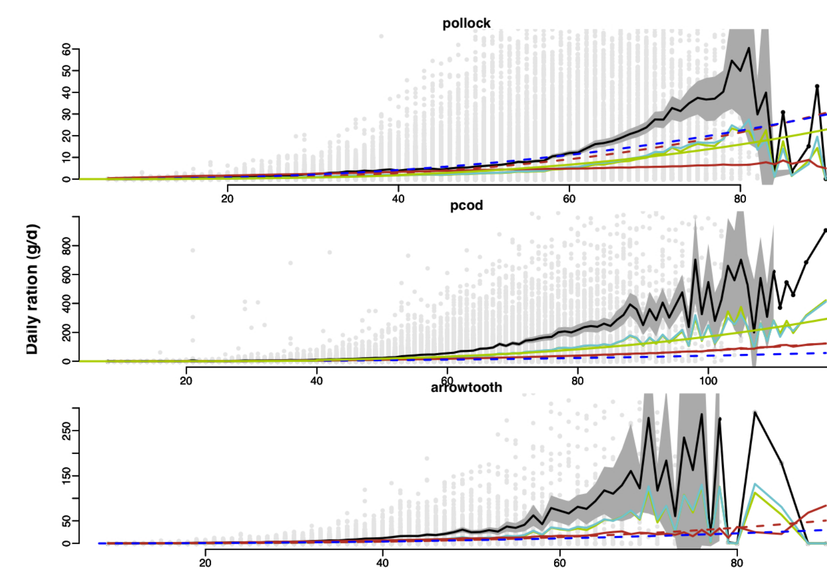


Figure 2. Daily size-dependent ration estimates for walleye pollock, Pacific cod, and arrowtooth flounder from the eastern Bering Sea. Shaded gray polygons represent the mean proportional weight of stomachs (gray dots; g stomach / g body weight), as compared to digestion corrected values (green lines; "livingston"), von Bertalanffy consumption estimates from two different fitting methods (blue and red lines), and Wisconsin bioenergetic model estimates (solid red lines).

Fish Stomach Collection and Lab Analysis

During the first quarter of 2012, Resource Ecology and Ecosystem Modeling (REEM) program staff conducted stomach contents analysis on samples from the Gulf of Alaska, Aleutian Islands, and Bering Sea. A total of 4,149 groundfish stomachs were analyzed. Three predator species were analyzed from the Gulf of Alaska, arrowtooth flounder was analyzed from the Aleutian Islands, and six predator species were analyzed from the Bering Sea. In total, 7,213 records were added to the North Pacific groundfish diet database. Octopod beaks found in the stomach contents (accumulated during the past year) were measured to estimate the prey-size of these octopods. In preparation for stable isotope analysis, 314 muscle and liver tissue samples from Alaskan groundfish were dried and homogenized. Fishery observers collected stomach samples from 17 arrowtooth flounder and 37 Pacific cod from the Aleutian Islands region; and 31 arrowtooth flounder, 117 Pacific cod, and 1,005 walleye pollock from the eastern Bering Sea fishing grounds.

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

Economics & Social Sciences Research Program

The Effects of Climate Regimes on the Bering Sea and Aleutian Islands Pacific Cod Longline Fishery

One component of the Bering Sea Integrated Ecosystem Research Program (BSIERP) funded by NPRB is an economic modeling project focused on the Bering Sea pollock and the Bering Sea Aleutian Islands (BSAI) Pacific cod fisheries. The "freezer longline" sector accounts for about half of the BSAI Pacific cod wholesale value of $435 million (2008). Climate change in the North Pacific may affect the distribution of Pacific cod and drive changes in the distribution of fishing. The study discussed here uses a retrospective examination of fishery responses to inter-annual climate variability to attempt to improve our ability to predict future fishery distributions under warmer climate conditions.

We investigate the relationship between survey abundance, climate regime, and fishery catch per unit effort (CPUE). We also investigate how harvesters respond to different fishery CPUE conditions. Vessel operators fish to maximize their net revenue, balancing the prices, catch rates, and costs of fishing in different areas. Higher CPUE increases net revenue, while the cost associated with greater travel decreases it, all other factors being equal. In this research, we focus in particular on how vessel trips change in relation to abundance and CPUE variation that may be driven by climate.

We find that in the winter season, fishery CPUE is higher in cold years. It then decreases in the summer season to levels indistinguishable from summer season CPUE in warm years. Variation in total abundance does not explain this trend because abundance was lower in the cold years, when high CPUE was observed. We posit that a large cold pool (< 2°C) concentrates fish in cold years, improving fishing conditions, and that this effect disappears as the cold pool dissipates in the summer fishing season. We also find that vessels make fewer long distance moves while fishing when CPUE is high, so that costs, in terms of the total distance traveled in a trip and the average number of sets per trip, are higher in warm years. This suggests that on average, costs may be higher in the fishery in future years if average annual temperatures increase.

By Alan Haynie and Lisa Pfeiffer

Because Alaska groundfish products are mainly exported, it was global market conditions that caused the negative price effects that dominated in 2009.

Analyzing the Economic Contribution of the Alaska Head and Gut Fleet Sector

First wholesale revenues of the Alaska groundfish fishery plunged by more than 25% in 2009 to $1.7 billion, down from $2.3 billion in 2008. While fish stock levels played a role (e.g., reductions in the pollock TAC), the change in total production was less than 6% (from 699.6 thousand metric tons (t) in 2008 down to 656.3 thousand t in 2009). Therefore, a sharp drop in market prices was the primary factor for the significant reduction of Alaska groundfish revenues in 2009. In fact, negative price effects were seen in a decomposition of the 2008-09 change in wholesale revenues across market categories (pollock, cod, flatfish, rockfish) and product groups (fillets, roe, surimi, and whole head & gut). Because Alaska groundfish products are mainly exported, it was global market conditions that caused the negative price effects that dominated in 2009. The Alaska Head and Gut (H&G) fleet was rationalized recently, and it relies on global markets as a primary source of revenue. Thus, an economic assessment of rationalization should consider the effects of global market conditions on benefits and costs.

In this project, we will develop a social accounting matrix (SAM) model that can be used to measure the contribution of the Alaska H&G fleet to the Alaska economy and calculate the economic impacts from a change in the global market conditions for the product (Alaska H&G) produced in this fleet. Because the currently available single-region Alaska regional economic models specify only one single rest of world (ROW) account, the project will need to disaggregate ROW into the rest of U.S. and foreign countries in order to examine the contribution and impacts of change in global market conditions. The SAM model can be used to quantify the contribution of an industry to a regional economy or to evaluate impacts of year-to-year changes in prices and quantities (e.g., total allowable catch) on regional employment and income. Regional economic models do not usually explicitly distinguish between domestic and foreign markets that are outside the regional economic zone, but that distinction is important for analyzing the regional impacts of price changes that are driven by global market conditions. The Alaska SAM model needs to distinguish between rest of U.S. and foreign countries. We will start from an existing Alaska SAM model and revise the model using U.S. trade statistics, the State of Alaska's Commercial Operators Annual Report (COAR), and H&G Fleet Economic Data Reports (which collect cost and earnings data from the H&G fleet). We will cooperate with industry in order to groundtruth the data for the fleet.

By Chang Seung and Michael Dalton

Estimating Economic Values for Saltwater Sport Fishing in Alaska Using Stated Preference Data

Knowing how anglers value their fishing opportunities is a fundamental building block of sound marine policy, especially for stocks for which there is conflict over allocation between different uses (e.g., allocation between recreational and commercial uses). This study reports on the results from an analysis of stated preference choice experiment data related to how recreational saltwater anglers value their catches and the regulations governing them of Pacific halibut, *Hippoglossus stenolepis*, Chinook salmon, *Oncorhynchus tshawytscha*, and coho salmon, *O. kisutch,* off the coast of Alaska.

The data used in the analysis are from a national mail survey conducted during 2007 of people who purchased sport fishing licenses in Alaska in 2006. The survey was developed with input collected through several focus groups and cognitive interviews with Alaska anglers, as well as from fishery managers. Each survey included several stated preference choice experiment questions, which asked respondents to choose between not fishing and two hypothetical fishing trip options that differ in the species targeted, length of the trip, fishing location, trip cost, and catch-related characteristics (including the expected catch and harvest restrictions). Responses to these questions were analyzed using random utility maximization-based econometric models. The model results were then used to estimate the economic value or willingness to pay that nonresident and Alaska resident anglers place on saltwater boat fishing trips in Alaska and assess their response to changes in characteristics of fishing trips.

The results show that Alaska resident anglers had mean trip values ranging from $246 to $444, while nonresidents had much higher values ($2,007 to $2,639), likely reflecting the fact that their trips are both less common and considerably more expensive to take. Nonresidents generally had significant positive values for increases in number of fish caught, bag limit, and fish size, while Alaska residents valued size and bag limit changes but not catch increases. The economic values are also discussed in the context of allocation issues, particularly as they relate to the sport fishing and commercial fishing sectors for Pacific halibut. A comparison of the marginal value of Pacific halibut in the two sectors suggests that the current allocation is not economically-efficient, as the marginal value in the sport sector is higher than in the directed halibut fishery in the commercial sector, which suggests that economic efficiency would increase if the sport sector were to have an increased allocation. Importantly, the results are not able to provide an estimate of how much allocation in each sector would result in the most efficient allocation, which requires additional data and analysis to fully estimate the supply and demand for Pacific halibut in each sector.

Knowing how anglers value their fishing opportunities is a fundamental building block of sound marine policy, especially for stocks for which there is conflict over allocation between different uses

By Dan Lew and Doug Larson

Improving Community Profiles for the North Pacific Fisheries

For the last 16 months, the Economic and Social Science Research (ESSR) program has been updating the Community Profiles of North Pacific Fisheries – Alaska. Community profiles are being drafted for 195 Alaskan communities that have ties to commercial, recreational, or subsistence fishing in the state. More communities may be added based on newly acquired data regarding subsistence fishing and marine mammal hunting in the state. Each updated community profile will report information on local demographics, the history of the community, natural resources, educational opportunities, the local economy, fisheries-related infrastructure, community finances, fisheries revenue, shore-based processing plants, landings and permits by species, and subsistence and recreational fishing participation, as well as information collected from communities in the Alaska Community Survey, which was implemented during summer 2011. In addition, regional profiles will be drafted that summarize overall involvement in fishing by communities in each of the major regions of Alaska. Drafts of each profile will be made available to each community for their review in late April and early May 2012. ESSRP researchers will incorporate any comments received to the extent possible. Final versions of the regional profiles and community profiles will be made available on the AFSC website as soon as community comments have been incorporated.

By Amber Himes-Cornell

Giant Pacific octopus on deck during the AFSC Aleutian Islands trawl survey. Photo by Christina Conrath, AFSC, Kodiak.

AFSC biologist Christina Conrath releases a giant Pacific octopus. Photo by Phillip Tschersich, ADF&G, Kodiak.

Discard Mortality for Octopus

A small octopus getting its length and weight recorded. Photo by M. Elizabeth Conners, AFSC, Seattle.

Among the many issues currently being discussed by the North Pacific Fishery Management Council's Plan Teams and AFSC scientists is a proposal to use discard mortality in catch accounting for the new Bering Sea and Gulf of Alaska octopus complexes. The Council has recently divided the old "other species" complex in both fishery management plans into separate management categories for sculpins, sharks, skates, squid, and octopus. Current federal regulations require that any of these species groups that are retained and sold must have an annual upper catch limit, even if they are not target species. Monitoring and regulating these groups separately will provide better overall ecosystem management, but some problems have come up due to the lack of data for many of the new groups. Octopus, in particular, is problematic because the AFSC bottom trawl surveys that are used to evaluate abundance of most groundfish do not work well for these animals. In 2011, the Bering Sea Plan Team set catch limits on the new octopus complex under Tier 6 of the Council's assessment structure, using the maximum of incidental catch taken from 1997-2007 as the overfishing limit (OFL) for this group. However, fishermen caught more octopus in the Bering Sea in 2011 than ever before, and reached the OFL in early October. The consequent early closure of the Pacific cod pot fishery has brought a lot of attention to the issues of these new species groups.

Octopus are different from most groundfish in that they do not have a swim bladder, so the sudden pressure changes from being brought to the surface do not cause traumatic injury. Fishermen and scientists observe that most octopus caught in cod pots are alive and very active when brought to the surface. Because of this, the octopus stock assessment author suggested that Plan Teams consider using a discard mortality factor in catch accounting for octopus. This is an approach in which the condition of a discarded animal is considered, and animals or fish that are expected to survive capture and discard are not counted toward the overall "take" of the fishery. Since many of the octopus caught are discarded rather than kept for market or bait, this method could reduce the impact of octopus bycatch on the Pacific cod fishery. At present, this approach is used in Alaska only for Pacific halibut. All other groundfish accounting uses the conservative assumption of 100% mortality for all fish caught, whether retained or discarded.

Data on the condition of discarded octopus was collected from 2006-07 and 2010-11 in an observer special project. Observers recorded the condition of octopus based on color and mobility and the presence of visible wounds. Data from both projects suggest that counting all discarded octopus as dead may be overestimating the impact of fishing on this group. In this study, less than 5% of the octopus caught with pot gear were dead or visibly injured when examined by observers. Approximately 20% of octopus in longline gear were dead or injured. Octopus caught in pelagic or bottom trawl nets were generally in poorer condition, probably because of the longer time between capture and processing. In trawl gear, 50%-85% of the octopus were dead or seriously injured.

Research needed for this approach is not complete. While the observer project data give us a good idea of what percentage of octopus are discarded in good condition, we still need to estimate how many of those discarded octopus survive to return to the bottom. AFSC scientists have proposed projects to look at the longer-term effects of capture and handling on octopus by holding caught octopus in running seawater tanks, either on board an actively fishing vessel or in the AFSC Kodiak Laboratory. Once these studies have been completed, the Council and Plan Teams can decide whether the extra complication of including discard mortality in octopus catch accounting is justified to improve the management of octopus and cod fisheries.

By M. Elizabeth Conners

Age & Growth Program

Preliminary Life History Variability of Longnose Skate (*Raja rhina*) Across Two Large Marine Ecosystems: Gulf of Alaska and California Current System

The longnose skate, *Raja rhina*, is common in the eastern North Pacific Ocean ranging from the Bering Sea to Baja California and occurs from inshore to a maximum of 1000 m depth. In the Gulf of Alaska (GOA), it has a maximum total length (TL) of 145 cm. A directed fishery for *Raja* spp. off Kodiak Island, Alaska, was initiated in 2003 and ended in 2005. An experimental fishery in Prince William Sound, Alaska was reinstated in 2009. The vulnerability of elasmobranchs to over exploitation from commercial fishing, either from bycatch or a directed fishery, is well documented. The Age and Growth (A&G) program recently completed a study in collaboration with Vladlena Gertseva (Northwest Fisheries Science Center), Jacquelynne King (Pacific Biological Station), and David Ebert (Pacific Shark Research Center). This inter-agency and institutional collaborative study quantitatively compared growth and age/size at sexual maturity of the longnose skate across two large marine ecosystems, the GOA and California Current Ecosystem (CCE).

Thoracic vertebrae (n = 838) were collected along with sex, maturity, and total length off the GOA, British Columbia (BC) and the U.S. west coast states (WC) between 2001 and 2009, May to August, via research surveys and port sampling (Fig.4). Vertebrae were thin sectioned (≈0.3 to 1.5 mm thick) on the longitudinal plane and microscope slide mounted. Growth bands were examined under a dissecting microscope with reflected or transmitted light with the addition of mineral oil for band enhancement. Opaque and translucent band pairs were interpreted as an annulus, 1 year of growth, from the corpus calcareum and intermedialia (Fig. 5). Ages were estimated from vertebrae prepared with the standard (unstained) thin sectioning method in this preliminary study (Fig. 5)

Reader-tester precision from all regions was: agreement [(±0) (4.0% to 35.2%)], CV (5.7 to 13.8) and APE (0.04 to 8.3) (+/-0 (plus or minus 0 years); CV (coefficient of variation); APE (average percent error). The length range for aged specimens and maximum age (26 years) are similar across all regions, while the L_{inf} values for males, females and sexes combined vary considerably (Table 1). The GOA male and female length distributions are skewed towards the greater lengths (> 1,000 mm TL) compared to BC and the WC. Male and female length distributions for BC and the WC are similar even with the WC sample size (*n* = 401) being more than double that of GOA and BC (Fig. 6). Overall, male and female von Bertalanffy growth curves show a greater length-at-age for GOA compared to BC and the WC. The GOA and the WC male growth curves converge at an age of 19 years and length of 1,200 mm (Fig. 6). Females from the GOA

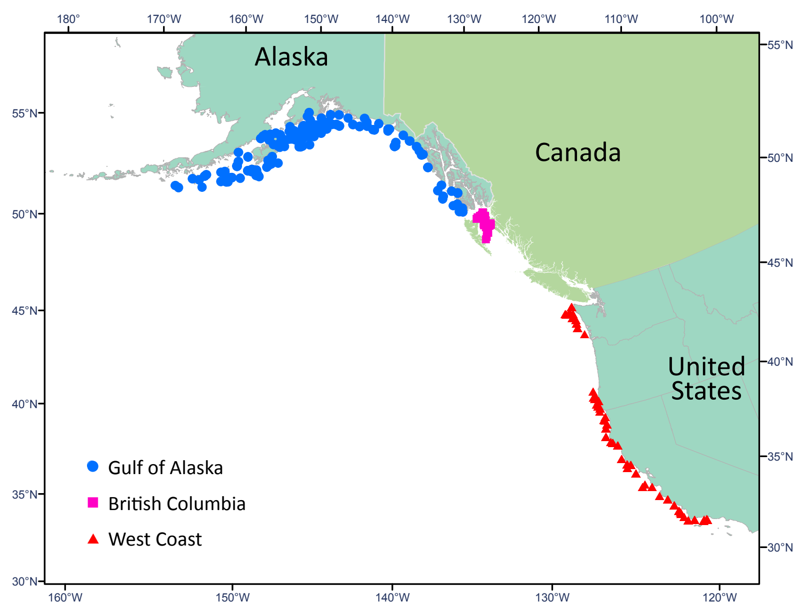


Figure 4. Longnose skate collection areas.

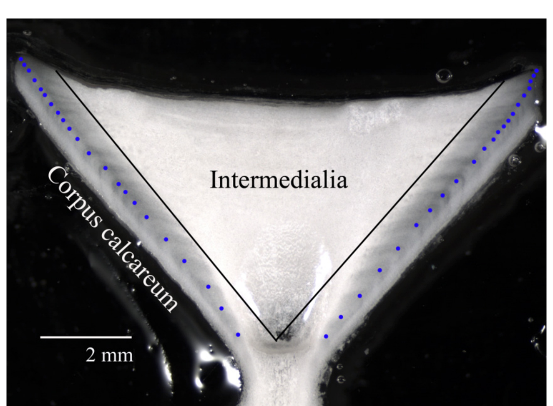


Figure 5. Longnose skate vertebral thin section (reflected light) prepared with the standard (unstained) method used for age estimates, aged at 22 years. Band pairs evident in the corpus calcareum and intermedialia

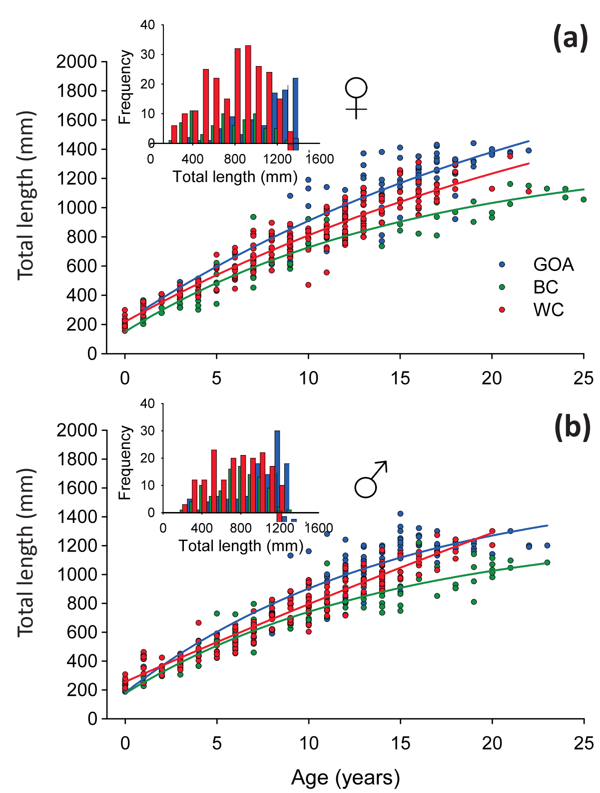


Figure 6. Average total length-at-age (von Bertalanffy growth curves) and frequency histograms from (a) females and (b) males; GOA (96 females, 115 males), BC (73 females, 101 males), WC (225 females, 176 males)

Table 1. A comparison of longnose skate sampling data, age and von Bertalanffy growth parameters by region. Numbers in brackets are 95% confidence intervals for parameter estimates; GOA (Gulf of Alaska); BC (British Columbia); WC (West Coast); TL (total length); Max Age (maximum age); L_{inf} (L infinity-theoretical asymptotic length); K (Brody growth coefficient); t_o (theoretical age at zero length); r^2 (coefficient of determination).

Region	Sex	n	TL Range (mm)	Max Age (year)	L_{inf} (mm TL)	K	t_o (year)	r^2
GOA	♂	115	210-1420	23	1649.6 [1298.6-2000.6]	0.068 [0.037-0.098]	-1.72 [-3.068-(-0.376)]	0.797
GOA	♀	96	340-1440	22	2384.6 [993.2-3776]	0.039 [0.0001-0.077]	-2.48 [-5.621-0.655]	0.742
GOA	♂ / ♀	211	210-1440	23	1943.5 [1501.4-2385.6]	0.052 [0.030-0.075]	-1.98 [-3.298-(-0.660)]	0.776
BC	♂	101	186-1220	23	1311.6 [1076.9-1546.4]	0.069 [0.041-0.097]	-2.09 [-3.405-(-0.775)]	0.871
BC	♀	73	184-1246	26	1371.8 [1132.0-1611.6]	0.064 [0.040-0.088]	-1.80 [-2.993-(-0.616)]	0.905
BC	♂ / ♀	174	184-1246	26	1337.9	0.067	-1.92	0.888
WC	♂	175	190-1290	20	[1177.2-1498.6] 11770.6 [-34436.9-57978.1]	[0.049-0.085] 0.005 [-0.015-0.025]	[-2.776-(-1.072)] -4.62 [-6.182-(-3.050)]	0.891
WC	♀	225	180-1420	22	2292.9 [1544-3042]	0.034 [0.018-0.050]	-2.97 [-3.833-(-2.112)]	0.903
WC	♂ / ♀	400	180-1420	22	3203.0 [1734.9-4671.1]	0.021 [0.009-0.034]	-3.62 [-4.405-(-2.840)]	0.987

and BC mature at a younger age than the WC. For the GOA and BC, females reach 50.0% sexual maturity at 11 years and at 17 years for the WC (Fig. 7). Differences in maturity characteristics, maturing or fully mature, and maturity stage assignment may explain the disparity between the GOA and BC/WC.

Future research will include re-evaluating and synchronizing ageing criteria upon completion of an initiated ^{14}C bomb-derived age validation study with the inter-agency age comparison of the standard thin section method and expansion of a histological hematoxylin staining technique. Environmental (e.g., bottom water temperature), oceanographic effects and potential influences on life history traits across the GOA and CCE ecosystems, including the 'current break' between the Alaska and California Current, will be evaluated.

By Christopher Gburski

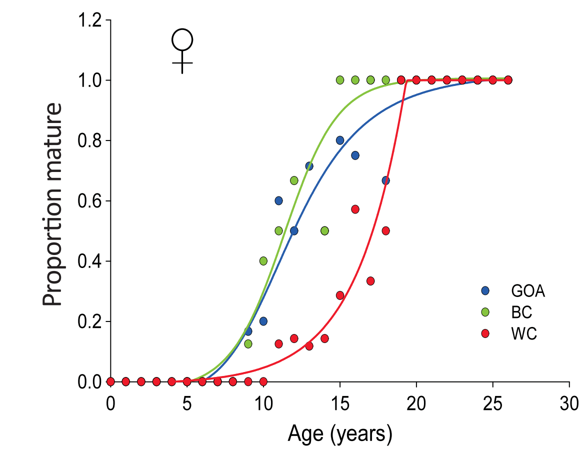


Figure 7. Age at proportion mature (logistic curves) for females; GOA (n = 96, BC (n = 73), WC (n = 225)

Age and Growth Program Production Numbers

Estimated production figures for 1 January – 31 March 2012. Total production figures were 9,027 with 1,961 test ages and 91 examined and determined to be unageable.

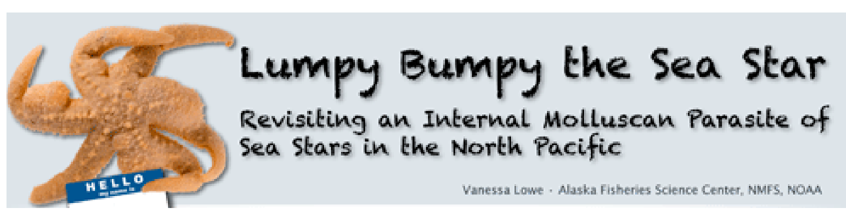
Species	Specimens Aged
Alaska plaice	565
Atka mackerel	413
Bering flounder	864
Blackspotted rockfish	210
Flathead sole	1,237
Great sculpin	51
Kamchatka flounder	1,058
Northern rock sole	385
Pacific cod	755
Rougheye rockfish	247
Walleye pollock	2,991
Yellowfin sole	251

By Jon Short

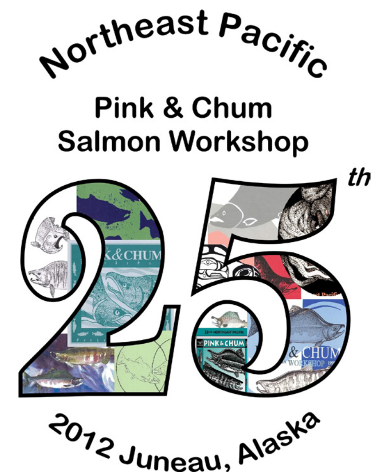
2012 National Shellfisheries Association Annual Meeting

Vanessa Lowe, Pam Jensen, and Frank Morado attended the National Shellfisheries Association annual meeting held 26–29 March 2012 in Seattle. Pam Jensen gave and oral presentation titled "*Hematodinium* spp. in the Pacific Northwest," a historical overview of *Hematodnium*-associated disease in the North Pacific. Vanessa presented the poster "Lumpy Bumpy the Sea Star,"which presented preliminary data on the effects and distribution of a gastropod parasite of sea stars. Dr. Joe Pitula of the University of Maryland Eastern Shore also attended the meeting which provided a background for collaborative disease studies.

By Frank Morado



The Pink and Chum Salmon Workshop was first started in 1962 in Juneau and continues to have a long legacy.



The 25th Northeast Pacific Pink & Chum Workshop

The 25th Northeast Pacific Pink and Chum Workshop was held in Juneau, Alaska, on 13-15 February 2012. A total of 110 participants contributed 56 oral or poster presentations at the workshop, with meeting participants from around the entire Pacific Rim including Alaska, Canada, Washington, Oregon, Japan, and Russia. The 3-day workshop was co-chaired by Joe Orsi and Emily Fergusson of the Center's Auke Bay Laboratories and Steve Heinl of the Alaska Department of Fish and Game. Additional organizational contributors to the workshop included the Canadian Department of Fisheries and Oceans, Douglas Island Pink and Chum Inc., the University of Alaska Fairbanks, the Pacific Salmon Commission, and Saint Hubert's Research Group.

A goal of the workshop is to facilitate the rapid exchange of findings and ideas by bringing together biologists, managers, researchers, and others in an informal setting to explore innovative research and management approaches and to expand our knowledge of the biology of pink and chum salmon populations. An exciting list of topics and speakers this year made the 2012 workshop productive and relevant to current issues facing these species. Workshop session topics included habitat restoration projects, genetics, fisheries management strategies, enhancement history, economics, conservation biology, stocks of concern, endangered species, resource stakeholder perspectives, salmon forecasting, modeling in ecosystems, and freshwater and marine ecology. Abstracts and poster presentations from the workshop are available online.

The Pink and Chum Salmon Workshop was first started in 1962 in Juneau and continues to have a long legacy. Traditionally, the workshop has occurred on alternate years and now is hosted rotationally among Alaska, British Columbia, and Washington. The next workshop is scheduled to be hosted by Washington in 2014.

By Joe Orsi, Emily Fergusson, and Molly Sturdevant

Pacific Seabird Group Meeting

The 39th annual meeting of the Pacific Seabird Group was held at the Turtle Bay Resort, Haleiwa, Hawaii on 7-11 February 2012. Center researchers Shannon Fitzgerald and Stephani Zador participated in a variety of activities. Fitzgerald gave an oral presentation in the Fisheries Interactions session titled "Seabird bycatch in Alaska trawl fisheries — A comparison of observer sampling protocols." This project, conducted collaboratively with seabird researcher Kim Dietrich, examined additional sources of mortality to seabirds that standard observer sampling cannot account for. The study focused on 9,000 trawl hauls that were observed using both standard and supplemental sampling in the years 2004-06 and 2009 (Fig. 1). A manuscript is being prepared that describes the results.

Zador gave an oral presentation titled "Eastern Bering Sea combined seabird indices show lagged effects of bottom temperature and food supply on reproduction." This project involved creating simplified indices that represent common trends among multiple seabird species and colonies (Fig. 2). These indices were found to be related to ecosystem processes at lagged time scales. Zador is lead author of a manuscript in preparation describing this work. Co-authors are Todd TenBrink, George Hunt, and Kerim Aydin. The new indices have already been incorporated into the Ecosystem Considerations report produced annually by the AFSC as part of the Groundfish Stock Assessment and Fishery Evaluation report. Fitzgerald, as a second author with William Walker, also presented the poster titled "Preliminary results on the diet of Laysan albatross and the use of fisheries by-caught birds in investigations of natural feeding strategy." AFSC posters are available on the REEM program website.

Fitzgerald also participated in the North Pacific Albatross Working Group and led agenda items on 1) the marine bird necropsy and food habits program for by-caught birds from observer programs throughout the North Pacific, 2) albatross bycatch in commercial fisheries, and 3) restructuring of the North Pacific Observer Program. The latter topic was requested by the American Bird Conservancy. Fitzgerald also met with representatives from the non-profit organization Oikonos, who are contracted to complete necropsy work, and with staff from the U.S. Fish and Wildlife Service, who collaborate with the AFSC on a wide variety of seabird/fishery interaction issues.

By Shannon Fitzgerald and Stephani Zador

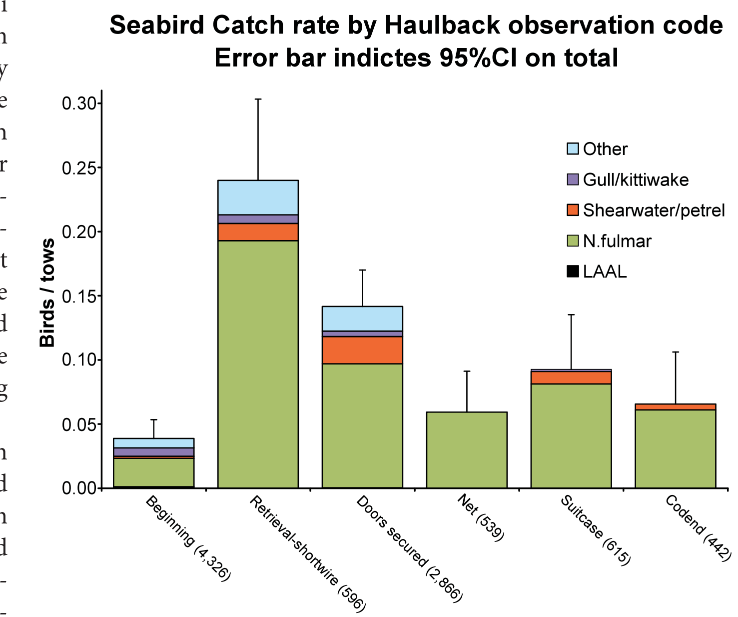


Figure 1. Comparison of seabird catch rates (birds/tow) at trawl haulback stages for Alaskan groundfish trawl vessels during an observer special project, 2004-2006 and 2009. The category "codend" represents standard observer sampling. Other categories represent the special project supplemental sampling completed by observers.

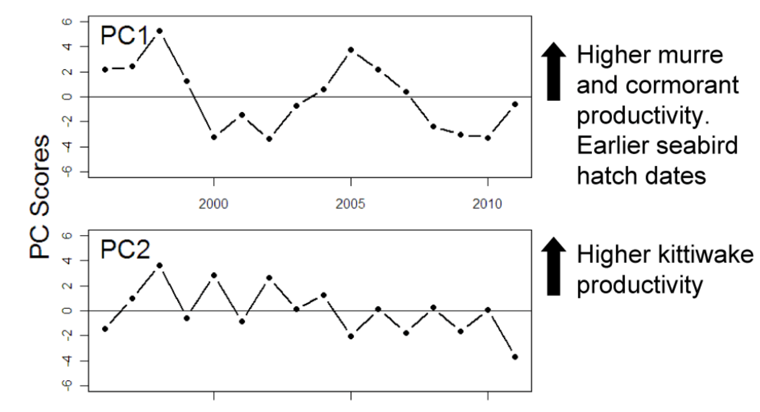


Figure 2. Eastern Bering Sea combined seabird index temporal trends. Seabird reproductive data are from the Pribilof Islands. Higher values of PC1 indicate earlier seabird hatch dates and higher cormorant and murre productivity (except for St. George Island thick-billed murres). Higher values of PC2 indicate higher kittiwake and St. George Island thick-billed murre productivity.

BSIERP Principal Investigators Meeting

The Bering Sea Integrated Ecosystem Research Program (BSIERP) is part of the Bering Sea Project, a multi-year partnership between the National Science Foundation and the North Pacific Research Board. The Bering Sea Project is a collection of 35 distinct but linked proposals that study climate, oceanography, zooplankton, fish, seabirds, marine mammals, fisheries, Native Alaskan communities and management. Every year, more than a hundred scientists from the Bering Sea Project get together to share and synthesize results of their ongoing research. As the project is in its last year, the March meeting in 2012 was the last of the Principal Investigator (PI) meetings, focusing on modeling results, applications and validation.

As part of the modeling effort, a vertically integrated model couples five distinct modules: climate, oceanography, nutrient-zooplankton, fish, and fisheries. The fish module called FEAST (Forage/Euphausiid Abundance in Space and Time) is fully coupled with the nutrient-zooplankton and fisheries components and will run both in hindcast and forecast mode. FEAST is a bioenergetics model that includes 12 fish species linked to five zooplankton groups and 20 fisheries specified by sector, gear, and target species. Species include walleye pollock, Pacific cod, arrowtooth flounder, salmon, capelin, herring, eulachon, sandlance and myctophids, squids, shrimp and epifauna; these have a two-way interaction with five groups from the nutrient-phytoplankton-zooplankton (NPZ) module: small/large copepods, oceanic/shelf euphausiids and benthos. Temperature and advection estimates from the physical oceanography portion (ROMS) are used in the fish bioenergetics, movement and reproduction components. The hindcast is compared both to time series and spatial patterns obtained from historical field data, stock assessments, and fishing effort data.

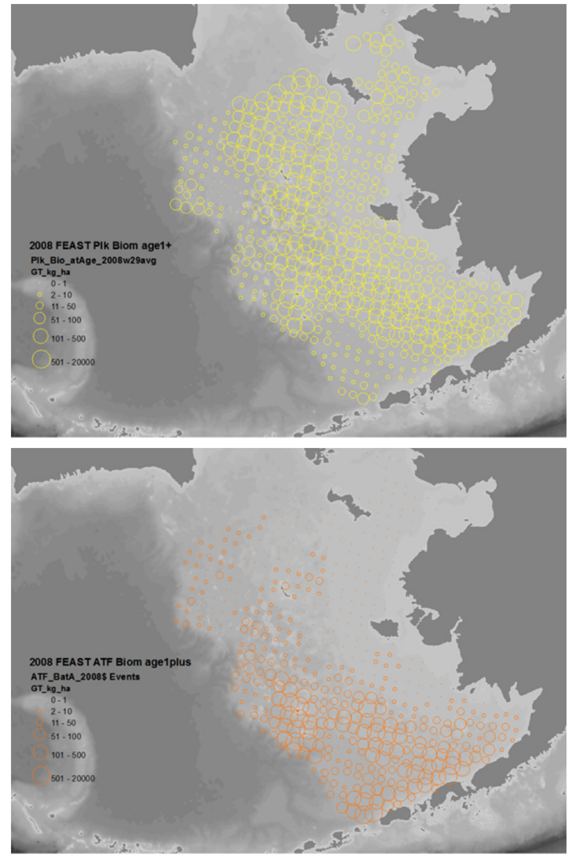


Figure 4. Fish distribution as predicted by FEAST for July 2008. Top panel shows total age 1+ biomass of pollock , bottom panel shows total age 1+ arrowtooth flounder biomass.

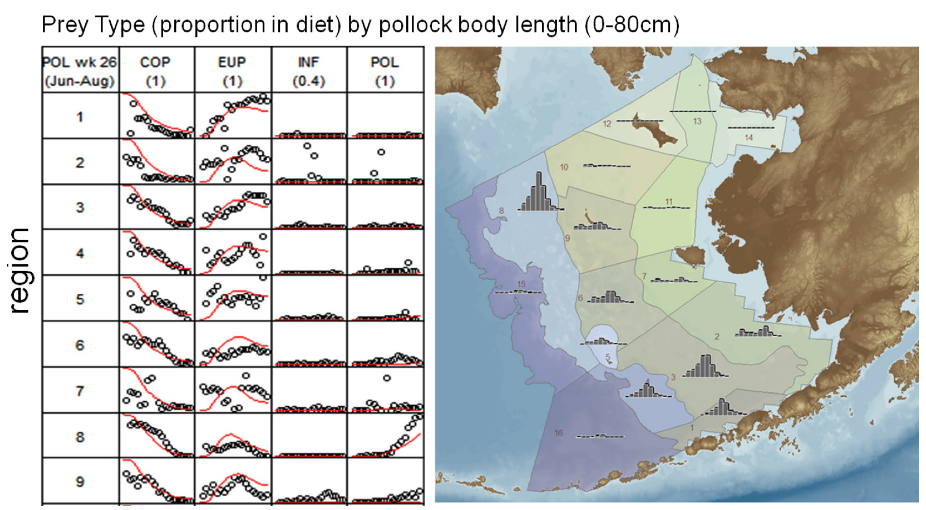


Figure 3. Pollock diets at different lengths, in nine different regions of the eastern Bering Sea. The marine regions shown in the right panel were drawn using GIS layers for multiple data seabirds, zooplankton, currents, etc. Column plots in each region show the number of stomachs available for different lengths of pollock. The panel on the left show the proportion in diet of a given prey for pollock at different lengths. Data is represented by circles, red lines represent model estimates.

For this last BSIERP PI meeting, Kerim Aydin and Ivonne Ortiz showed a comparison of data versus model outputs, highlighting the model's ability to capture prey switching, species distribution based on temperature and prey availability, interannual differences between cold and warm years, and preferred temperature ranges for walleye pollock, Pacific cod, and arrowtooth flounder. A large part of the parameter estimation for FEAST was based on the extensive food habits database supported by the program since 1982. Figure 3 shows diets for pollock at different lengths, which are at the core of the FEAST model. Figure 4 shows model distributions for pollock, cod, and arrowtooth for July 2008. Fish movement and growth is estimated the same way for all three species, with species-specific bioenergetics and prey preferences dictating the movement and growth of each species. FEAST will be used as the model representing the real world in the Management Strategy Evaluation project part of BSIERP.

At the meeting Liz Moffitt, Kerim Aydin, Ivonne Ortiz, Andre Punt, Anne Hollowed, and Gordon Kruse met to discuss the preliminary results of developing multi-species harvest control rules. This step is key in using multi-species assessment models for fisheries management, both in general and for the Management Strategy Evaluation project of BSIERP. Many good points were brought up by the group in terms of priorities in moving forward. This work is ongoing and includes the work of Kirstin Holsman, who was not able to travel to the meeting.

By Ivonne Ortiz, Liz Moffitt, and Kerim Aydin

SSC Workshop on Use of Stock-Recruitment Relationships in Stock Assessments

At the North Pacific Fishery Management Council's December 2011 meeting, the Scientific and Statistical Committee (SSC) chose stock-recruitment (SR) issues as its topic for its upcoming workshop, which was held 1 February 2012, in conjunction with the February SSC meeting. Many Status of Stocks and Multispecies Assessments (SSMA) program staff and collaborators provided presentations on relevant topics. Megan Stachura (graduate student at the University of Washington, (UW)), Cody Szuwalski (UW), and Teresa A'mar considered analytical approaches to address regime shifts in stock production. These presentations applied statistical methods to identify shifts in recruitment and evaluated the implications of shifting time frames on harvest control strategies. Jim Ianelli and Tom Wilderbuer introduced approaches in which variables representing environmental forcing are incorporated into the SR relationship. Martin Dorn, Grant Thompson, and Jim Ianelli showed different approaches to incorporate spawner recruitment relationships into stock assessments. Martin Dorn noted that west coast assessment scientists estimate the steepness parameter of the stock recruitment relationship either with a prior based on a meta analysis of groundfish stock recruitment, or by fixing steepness at the mean of the meta analysis. Grant Thompson introduced a statistical method to estimate mean recruitment and sigma *R*. Jim Ianelli provided an example where he conditioned the spawner-recruit parameters on the basis of the assumption that $F_{35\%}$ was equal to F_{MSY}.

Workshop participants discussed the criteria needed to transition a stock to Tier 1 and commented that the posterior distribution function of F_{MSY} should incorporate several sources of error in growth, natural mortality, selectivity, and the SR relationship. The SSC and Plan Team members discussed timelines to continue research on this topic. The SSC recommended, and the Plan Team concurred, that the next step would be to hold a workshop to develop guidelines on how to accommodate environmental changes in the SR relationship into the calculation of biological reference points and how to model environmental forcing in stock projection models. This workshop will be held at the Center on 4-5 April 2012.

By Anne B. Hollowed

Western Groundfish Conference

The Western Groundfish Conference has always been a unique opportunity to review current research and management concerning West Coast groundfish resources, including fishery biology, stock assessment, survey methodology, fishery monitoring, ecosystem analysis, conservation, habitat studies, and advanced technologies. Over 210 scientists and students attended this year's conference in Seattle on 6-10 February 2012, with 87 oral presentations and 59 posters. Main themes included life history and ecosystem processes, habitat and distribution, fishery monitoring and management, survey methods, and stock assessment (Fig. 1). Organizers from the AFSC were Wayne Palsson, Jim Ianelli, Susanne McDermott, Lyle Britt, Mark Zimmerman, Lynn Lee, and emeritus Mark Wilkins. As always, the informal conference atmosphere encouraged dialog among various stakeholders, including members from science, industry, conservation groups, government, and other organizations.

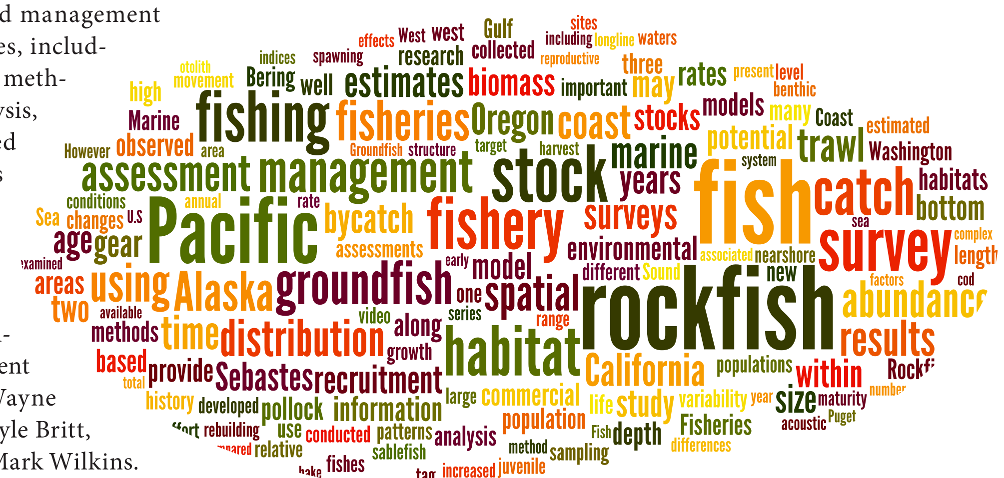


Figure 1. Word cloud of abstracts submitted at the 2012 Western Groundfish Conference sponsored in part by the AFSC and coordinated by a number of AFSC scientists.

The conference also included a workshop on Pacific cod with over 50 participants from Alaska, Oregon, Washington, and British Columbia. One of the goals of this workshop was to bring together scientists from different backgrounds, agencies, and research expertise to share research ideas and encourage collaboration amongst scientists. The other workshop goal was to identify data gaps and research needs for four main research topics: stock assessment, stock structure and adult movement, early life history, reproductive biology, growth, and ecology and the effects of climate change on cod stocks. Short overviews of each topic were presented and current data gaps and research themes were developed and prioritized.

By Susanne McDermott, Wayne Palsson, and Jim Ianelli

Publications and reports for January–February–March 2012.
Authors citing affiliation with the AFSC are denoted in **boldface**.

Boldt, J.L., S.C. Bartkiw, P.A. Livingston, G.R. Hoff, and G.E. Walters.
2012. Investigation of fishing and climate effects on the community size spectra of eastern Bering Sea fish. Trans. Am. Fish. Soc. 141:327-342.

Call, K.A., and R.R. Ream.
2012. Prey selection of subadult male northern fur seals (Callorhinus ursinus) and evidence of dietary niche overlap with adult females during the breeding season. Mar. Mammal Sci. 28(1):1-15.

Clapham, P.J.
2011. Mr. Melville's whale. Am. Sci. 99:505.

Clarke, J.T., C.L. Christman, A.A. Brower, M.C. Ferguson, and S.L. Grassia (editors).
2011. Aerial surveys of endangered whales in the Beaufort Sea, fall 2010. Annual Report OCS Study BOEMRE 2011-035, 120 p. Natl. Mar. Mammal Lab., Alaska Fish. Sci. Cent., 7600 Sand Point Way NE, Seattle WA 98115.

De Robertis, A., C. Wilson, and N.J. Willamson.
2012. Do silent ships see more fish? Comparison of a noise-reduced and a conventional research vessel in Alaska, p. 331-334. In A. N. Popper, and A. Hawkins (editors), The Effects of Noise on Aquatic Life, Advances in Experimental Medicine and Biology Vol. 730.

Doney, S.C., M. Ruckelshaus, J.E. Duffy, J.P. Barry, F. Chan, C.A. English, H.M. Galindo, J.M. Grebmeier, A.B. Hollowed, N. Knowlton, J. Polovina, N.N. Rabalais, W.J. Sydeman, and L.D. Talley.
2012. Climate change impacts on marine ecosystems. Annu. Rev. Mar. Sci. 4:11-37.

Eberhardt, L.L., and J.M. Breiwick.
2012. Models for population growth curves. ISRN Ecology 2012, Article ID 815016. 7 p.

Foster, E.A., D.W. Franks, L.J. Morrell, K.C. Balcomb, K.M. Parsons, A. Van Ginneken, and D.P. Croft.
2012. Social network correlates of food availability in an endangered population of killer whales, Orcinus orca. Anim. Behav. 83(3):731-736.

Goetz, K.T., R.A. Montgomery, J.M. Ver Hoef, R.C. Hobbs, and D.S. Johnson.
2012. Identifying essential summer habitat of the endangered beluga whale Delphinapterus leucas in Cook Inlet, Alaska. Endang. Species Res. 16:135–147.

Gray, M.A., R.P. Stone, M.R. McLaughlin, and C.A. Kellogg.
2011. Microbial consortia of gorgonian corals from the Aleutian Islands. FEMS Microbiol. Ecol. 76(1):109–120.

Hanselman, D.H., and T.J. Quinn II.
2004. Sampling rockfish populations: Adaptive sampling and hydroacoustics, p. 271-296. In W. Thompson (editor), Sampling Rare or Elusive Species. Island Press, Washington D.C.

Heard, W.R.
2011. Comparison of salmon hatchery programs in Alaska and Japan, p. 71-78. In R. Stickney, R. Iwamoto, and M. Rust (editors), Proceedings of the Thirty-eighth U.S.-Japan Aquaculture Panel Symposium. Oct. 26-27, 2009, Texas A&M University, Corpus Christi, Texas. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-113.

Helser, T.E., and L. Alade.
2012. A retrospective of the hake stocks off the Atlantic and Pacific coasts of the United States: Uncertainties and challenges facing assessment and management in a complex environment. Fish. Res. 114:2–18

Honkalehto, T., P.H. Ressler, R.H. Towler, and C.D. Wilson.
2011. Using acoustic data from fishing vessels to estimate walleye pollock (Theragra chalcogramma) abundance in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 68:1231–1242.

Hulson, P-J. F., S.E. Miller, J.N. Ianelli, and T.J. Quinn II.
2011. Including mark-recapture data into a spatial age-structured model: Walleye pollock (Theragra chalcogramma) in the eastern Bering Sea. Can. J. Fish. Aquat. Sci. 68(9):1625-1634.

Hutchinson, C.E., and T.T. Tenbrink.
2011. Age determination of the yellow Irish lord: Management implications as a result of new estimates of maximum age. N. Am. J. Fish. Manage. 31:1116-1122.

Ivashchenko, Y.V., P.J. Clapham, and R.L. Brownell, Jr.
2011. Soviet illegal whaling: the devil and the details. Mar. Fish. Rev. 73(3):1-19.

Kastelle, C.R., T.E. Helser, B.A. Black, M.J. Stuckey, D.C. Gillespie, J. McArthur, D. Little, K.D. Charles, and R.S. Khan.
2011. Bomb-produced radiocarbon validation of growth-increment crossdating allows marine paleoclimate reconstruction. Palaeogeogr., Palaeoclimatol., Palaeoecol. 311:126–135.

Lehnert, H., and R.P. Stone.
2011. Craniella sputnika sp. nov. (Porifera: Spirophorida: Tetillidae) from the Aleutian Islands, Alaska, with suggested nomenclatural changes for the genera Tetilla and Craniella. J. Mar. Biol. Assoc. UK. 91(2):321-328.

Liu, J.X, A. Tatarenkov, T.D. Beachman, V. Gorbachev, S. Wildes, and J.C. Avise.
2011. Effects of Pleistocene climatic fluctuations on the phylogeographic and demographic histories of Pacific herring (Clupea pallasii). Mol. Ecol. 20(18):3879-93.

Long, W.C., and A.H. Hines.
2012. Scale and the guild functional response: Density-dependent predation varies with plot size. J. Exp. Mar. Biol. Ecol. 413:50–55.

Miller R.J., J. Hocevar, R.P. Stone, and D.V. Fedorov.
2012. Structure-forming corals and sponges and their use as fish habitat in Bering Sea submarine canyons. PLoS ONE 7(3):e33885.

Moore, J.E., and R. Merrick (editors) with contributions from: R. Angliss, J. Barlow, S. Bettridge, J. Carretta, T. Eagle, C. Fahy, P. Rosel, M. Simpkins, B. Taylor, and P. Wade.
2011. Guidelines for assessing marine mammal stocks: Report of the GAMMS III Workshop, February 15-18, 2011, La Jolla, California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-47, 95 p.

Mulukutla, G.K., L.C. Huff, J.S. Melton, K.C. Baldwin, R.A. McConnaughey, and L.A. Mayer.
2011. Erratum to: Sediment identification using free fall penetrometer acceleration-time histories [Mar. Geophys. Res. 32:397-411]. Mar. Geophys. Res. 32:413.

Norman, S.A., C.E. C. Goertz, K.A. Burek, L.T. Quakenbush, L.A. Cornick, T.A. Romano, T. Spoon, W. Miller, L.A. Beckett, And R. C. Hobbs.
2012. Seasonal hematology and serum chemistry of wild beluga whales (Delphinapterus leucas) in Bristol Bay, Alaska, USA. J. Wildl. Dis. 48(1):21-32.

Palof, K.J., J. Heifetz, and A.J. Gharrett.
2011. Geographic structure in Alaskan Pacific ocean perch (Sebastes alutus) indicates limited lifetime dispersal. Mar. Biol. 158:779–792.

Reynolds, J.R., S.C. Rooney, J. Heifetz, H.G. Greene, B.L. Norcross, and S.K. Shotwell.
2012. Habitats and demersal fish communities in the vicinity of Albatross Bank, Gulf of Alaska, p. 539-553. In P.T. Harris and E.K. Baker (editors), Seafloor Geomorphology as Benthic Habitat. Elsevier.

Rodgveller, C.J., C.R. Lunsford, and J.T. Fujioka.
2012. Effects of maternal age and size on embryonic energy reserves, developmental timing, and fecundity in quillback rockfish (Sebastes maliger). Fish. Bull., U. S. 110:35–45.

Rooper, C.N., and M.H. Martin.
2012. Comparison of habitat-based indices of abundance with fishery-independent biomass estimates from bottom trawl surveys. Fish. Bull., U. S. 110:21-35.

Schmidt, J.H., M.S. Lindberg, D.S. Johnson, and D.L. Verbyla.
2011. Season length influences breeding range dynamics of trumpeter swans Cygnus buccinator. Wildl. Biol. 17(4):364-372.

Seeb, L.W., J.E. Seeb, C. Habicht, E.V. Farley, Jr., and F.M. Utter.
2011. Single-nucleotide polymorphic genotypes reveal patterns of early juvenile migration of sockeye salmon in the eastern Bering Sea. Trans. Am. Fish. Soc. 140(3):734-748.

Shertzer, K.W., and P.B. Conn.
2012. Spawner-recruit relationships of demersal marine fishes: Prior distribution of steepness. Bull. Mar. Sci. 88(1):39-50.

Stark, J.W.
2011. Contrasting the maturation, growth, spatial distribution and vulnerability to environmental warming of Hippoglossoides robustus (Bering flounder) with H. elassodon (flathead sole) in the eastern Bering Sea. Mar. Biol. Res. 7:778-785.

Stark, J.W.
2012. Contrasting maturation and growth of northern rock sole in the eastern Bering Sea and Gulf of Alaska for the purpose of stock management. N. Am. J. Fish. Manage. 32:93-99.

Stark, J.W.
2012. Female maturity, reproductive potential, relative distribution, and growth compared between arrowtooth flounder (Atheresthes stomias) and Kamchatka flounder (A. evermanni) indicating concerns for management. J. Appl. Ichthyol. 28: 226–230.

Stoner, A.W.
2012. Evaluating vitality and predicting mortality in spot prawn, Pandalus platyceros, using reflex behaviors. Fish. Res. 119/120:108–114.

Stachura, M.M., C.R. Lunsford, C.J. Rodgveller, and J. Heifetz.
2012. Estimation of discard mortality of sablefish (Anoplopoma fimbria) in Alaska longline fisheries. Fish. Bull., U.S. 110:271-279.

Tribuzio, C.A., and G.H. Kruse.
2011. Demographic and risk analyses of spiny dogfish (Squalus suckleyi) in the Gulf of Alaska using age- and stage-based population models. Mar. Freshw. Res. 62(12):1395-1406.

Waite, J.N., V.N. Burkanov, and R.D. Andrews.
2012. Prey competition between sympatric Steller sea lions (Eumetopias jubatus) and northern fur seals (Callorhinus ursinus) on Lovushki Island, Russia. Can. J. Zool. 90(1):110-127.

Walline, P.D., C.D. Wilson, A.B. Hollowed, and S.C. Stienessen.
2012. Short-term effects of commercial fishing on the distribution and abundance of walleye pollock (Theragra chalcogramma). Can. J. Fish. Aquat. Sci. 69:354–368.

Waters, E.C., and C.K. Seung.
2010. Impacts of recent shocks to Alaska fisheries: a computable general equilibrium (CGE) model analysis. Mar. Resour. Econ. 25:155-183.

Wilson, K., L. Fritz, E. Kunisch, K. Chumbley, and D. Johnson.
2012. Effects of research disturbance on the behavior and abundance of Steller sea lions (Eumetopias jubatus) at two rookeries in Alaska. Mar. Mammal Sci. 28:E58-E74.

Witteveen, B.H., J.M. Straley, E. Chenoweth, C.S. Baker, J. Barlow, C. Matkin, C.M. Gabriele, J. Neilson, D. Steel, O. Von Ziegesar, A.G. Andrews, and A. Hirons.
2011. Using movements, genetics and trophic ecology to differentiate inshore from offshore aggregations of humpback whales in the Gulf of Alaska. Endang. Species Res. 14: 217-225.

Woillez, M., P.H. Ressler, C.D. Wilson, and J.K. Horne.
2012. Multifrequency species classification of acoustic-trawl survey data using semi-supervised learning with class discovery. J. Acoust. Soc. Am. 131(2):EL184-EL190.

Wright, S.K., and J.R. Moran.
2011. Ocean-going vessels: a possible conduit for the introduction of white-nose syndrome fungus (Geomyces destructans) into bats in Alaska. Northwest. Nat. 92(2):133-135.

NOAA Tech Memos[1]

Guthrie, C.M. III, H.T. Nguyen, and J.R. Guyon.
2012. Genetic stock composition analysis of chinook salmon bycatch samples from the 2010 Bering Sea trawl fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-232, 22 p.

Kondzela, C.M., W.T. McCraney, H.T. Nguyen, and J.R. Guyon.
2012. Genetic stock composition analysis of chum salmon bycatch samples from the 2010 Bering Sea groundfish fisheries. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-233, 29 p.

AFSCProcessedReports[2]

Honkalehto, T., A. McCarthy, P. Ressler, K. Williams, and D. Jones.
2012. Results of the acoustic-trawl survey of walleye pollock (Theragra chalcogramma) on the U.S. and Russian Bering Sea shelf in June - August 2010 (DY1006). AFSC Processed Rep. 2012-01, 57 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Low, L-L.
2012. National Marine Fisheries Service Workgroup Report on Encounter Protocol on Vulnerable Marine Ecosystems in the North Pacific Fisheries Commission Area. AFSC Processed Rep. 2012-02, 34 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Goetz, K.T., P.W. Robinson, R.C. Hobbs, K.L. Laidre, L.A. Huckstadt, and K.E.W. Shelden.
2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03,40 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

[1] The NOAA Technical Memorandum series NMFS AFSC (formerly F/NWC) is a Center publication which has a high level of peer review and editing. The Technical Memorandum series reflects sound professional work and may be cited as publications. Copies may be ordered from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161 or at www.ntis.gov.

[2] The AFSC Processed Report series is not formally reviewed and individual reports do not constitute publications. The reports are for information only and a limited number of copies are available from the author.

The National Marine Fisheries Service
(NOAA Fisheries Service) is an agency within the
National Oceanic and Atmospheric Administration (NOAA)
of the U.S. Department of Commerce

The mission of the NOAA Fisheries Service is to provide stewardship of the nation's living marine resources through science-based conservation and management and promotion of healthy ecosystems

Alaska Fisheries Science Center
7600 Sand Point Way N.E.
Seattle, Washington 98115

www.afsc.noaa.gov/quarterly/