NOAA's "Home Run" Pink Salmon Forecast Materializes in 2011 and Allows Southeast Alaska Resource Stakeholders to Optimize a 58M Fish Harvest Valued at >$95M

Pink salmon are notoriously difficult to forecast due to their highly variable ocean mortality and their brief 1½ year ocean residence, both of which preclude managers from using leading indicator year-class information. For the past 8 years, the AFSC has provided pink salmon forecasts to resource stakeholders in Southeast Alaska. These forecasts are made possible by a small team of scientists who have maintained the AFSC's Southeast Alaska Coastal Monitoring (SECM) project since 1997. The SECM project studies the marine ecosystem of Southeast Alaska and the adjacent Gulf of Alaska to better understand essential fish habitat, climate change, and factors responsible for fishery recruitment, including highly migratory species such as Pacific salmon. These SECM forecasts are based on metrics associated with juvenile salmon sampled by surface trawls fished miles offshore in regional migration corridors, including both regional physical conditions and basin-scale factors operating in the Gulf of Alaska. The NOAA data is shared with the Alaska Department of Fish and Game (ADF&G), which modifies its regional forecast based on SECM "juvenile pink" data. The NOAA forecast information is presented at a Southeast Alaska regional meeting, the Purse Seine Task Force, which is well attended by fishers, processors, industry representatives, managers, researchers, and reporters.

Pink salmon harvests in Southeast Alaska have ranged from 12 to 45M fish over the past 5 years, with an overall average harvest of about 26M fish. In contrast, based on the SECM survey data from the 2010 sampling year, the NOAA pink salmon forecast for 2011 was 56.2M fish, an anticipated harvest more than double the recent 5-year average. At the writing of this article, the total Southeast Alaska pink salmon harvest for 2011 is 58.5M fish. A high market demand for salmon in 2011 has contributed to increased value of the catch. Consequently, the 2011 harvest has an ex-vessel commercial value of about $96M U.S. dollars about triple the next highest value year over the past 15 years. Moreover, to put this excellent Southeast Alaska pink salmon catch into a numerical perspective, it represents over one-third of the total numbers of salmon commercially harvested in Alaska from all salmon species in 2011. Southeast Alaska pink salmon stocks originate from over 2,000 stream systems in the region, are 98% wild, and are actively managed in-season by the ADF&G. Without the foresight of this high forecast for pink salmon in 2011, processors and fisherman may not have been prepared to handle this volume of commercial catch, and thus the NOAA data permitted optimal harvest and processing strategies to be anticipated and planned out. For more information on NOAA pink salmon forecasts and methodology, please see: http://www.afsc.noaa.gov/ABL/MSI/msi_sae_psf.htm

By Joe Orsi

Workshop on Top-Down Control of Pacific Herring (*Clupea pallasii*) in the Gulf of Alaska

The Nutritional Ecology Lab hosted a workshop at the Ted Stevens Marine Research Institute in Juneau, Alaska, on 12 September 2011 to discuss "Top-Down Control of Herring (*Clupea pallasii*) in the Gulf of Alaska." The workshop marks the completion of several multi-year collaborative studies funded by the *Exxon Valdez* Oil Spill Trustee Council to weigh the evidence for top-down control of herring in Prince William Sound. The objective of the workshop was to synthesize the results from these studies that quantify predation impact on herring and to weigh the evidence for top-down control, particularly in Prince William Sound. The product of the workshop will be the collection of manuscripts from these studies in a special issue of a journal with an overarching summary framed from the workshop discussion. A summary of the workshop follows.

Humpback whales are one of the most conspicuous herring predators in the Gulf of Alaska (GOA), and they are increasing in abundance at a rapid rate (4%-7%/year). Since the cessation of whaling in 1966, humpback abundance has recovered and now exceeds that of pre-whaling days. We quantified the significance of humpback whale predation on herring in winter when herring form large aggregations and whales are building their energy reserves for their annual breeding migrations. Whale predation was compared amongst three GOA herring stocks, including depressed herring stocks in Prince William Sound and Lynn Canal and a robust stock in Sitka Sound. We determined that humpbacks had the greatest impact on herring in Prince William Sound, where whales were most abundant and remained longer into the winter. Observations of feeding whales and isotopic and fatty acid analysis of blubber indicated that in Prince William Sound, whales foraged on herring for a longer period of time into winter in contrast to Sitka where the greatest proportion of whales were feeding on krill. Prolonged foraging on herring in Prince William Sound may be due to absence of alternate prey or a preference for herring. Bioenergetic modeling efforts reveal that humpbacks remove the highest proportion of herring biomass in depressed areas, in quantities similar to that of a commercial fishery (more than 20% in Prince William Sound and Lynn Canal versus 1% in Sitka). This equates to approximately 3,500 metric tons (t) of herring consumed over winter in Prince William Sound, 900 t in Sitka, and 600 t in Lynn Canal. Foraging by humpback whales may disrupt herring school formation at depth, facilitating foraging by other air-breathing predators including Steller sea lions and sea birds.

Similar surveys and bioenergetic modeling efforts were conducted to quantify winter predation on herring by seabirds in Prince William Sound from 1990 to 2007. Eighteen species of marine birds were identified as herring predators, with consumption estimates being driven by common murres that were more abundant than other species by 1-2 orders of magnitude. On average, seabirds consumed approximately 2,400 t of herring per winter. Modeling results indicate that biomass of juvenile herring consumed may be twice that of adults. This represents an average removal of 6% of the adult herring biomass, and as much as 10% in years with low herring biomass and high murre abundance. Evidence of top-down control by seabirds was observed using a lag analyses in which seabird consumption of adult herring was negatively correlated with miles of spawn observed the following year.

Similarly, a retrospective analysis was conducted to look for relationships in humpback whale and herring abundances in Prince William Sound over time. Incorporation of whale-derived mortalities in the herring age-structured assessment (ASA) model revealed a relationship between whale abundance and that of older herring (ages 5+), but not younger age classes (ages 3-4). Though the modeling results indicated that humpback predation could be substantially impacting the biomass of older herring, removal of whale predation from the model did not substantially affect the resulting biomass of herring. This suggests that whale-derived mortality was less important than recruitment on biomass. Further, the whale-adjusted ASA model indicated that whale-induced mortalities increased at the same time periodic recruitment became significantly hindered.

To examine the potential for impaired recruitment to structure the Prince William Sound herring stock, two mechanisms of recruitment were compared between three Gulf of Alaska herring stocks over three winters, including reproductive investment of adults and juvenile mortality. We examined the potential influence of winter on Pacific herring by contrasting the winter energy consumption of juveniles and adults from three stocks around the Gulf of Alaska. In addition, we performed laboratory studies aimed at understanding how metabolic rates scale with temperature and estimating the energy cost associated with disease infection. These analyses indicated that the sensitivity of juvenile herring to winter varies spatially as a result of differences in food availability and sources of energetic costs. A direct consequence of this variation is that juveniles in different locations begin spring in different nutritional states. In addition, we determined that juvenile herring undergo compensatory growth in spring and the degree of compensation depends on the nutritional status at the end of winter. Laboratory studies demonstrate that the presence of disease in juvenile herring can impair compensation by imposing a metabolic cost. These factors likely interact to influence recruitment of juvenile herring into spawning populations and suggest recruitment models in stock assessments can be improved by monitoring juvenile condition and abundance. In contrast, winter appears to have less influence on the amount of energy allocated to gonadic tissues in adult herring.

By Ron Heintz and Johanna Vollenweider

Energetic Cost of *Ichthyophonus* Infection in Juvenile Pacific Herring

Ichthyophonus is a commonly occurring parasite that has been reported in more than a hundred species of fish. It is highly pathogenic to Pacific herring, and occurs in high prevalence and intensity in herring populations throughout the northeast Pacific Ocean. Outbreaks of the parasite are known to structure herring populations.

The energetic costs of fasting and *Ichthyophonus* infection were measured in juvenile Pacific herring in a lab setting at three temperatures. Infected herring incurred significant energetic costs, the magnitude of which depended on fish condition at the time of infection (fat versus lean). Herring that were fed continually and were in relatively good condition at the time of infection (fat) never stored lipid despite ad libitum (free) feeding. In feeding herring, the energetic cost of infection was a 30% reduction in total energy content relative to controls 52 days post infection (Fig. 1). Following food deprivation (lean condition), infection caused an initial delay in the compensatory response of herring. Thirty-one days after re-feeding, the energetic cost of infection in previously-fasted fish was a 32% reduction in total energy content relative to controls (Fig. 2). Body composition of infected herring subsequently recovered to some degree, though infected herring never attained the same energy content as their continuously fed counterparts. Fifty-two days after re-feeding, the energetic cost of infection in previously-fasted fish was a 6% reduction in total energy content relative to controls. The greatest impacts of infection occurred in colder temperatures, suggesting *Ichthyophonus*- induced reductions in body condition may have greater consequences in the northern extent of herring's range, where juveniles use most of their energy reserves to survive their first winter (Fig. 3).

By Johanna Vollenweider and Ron Heintz

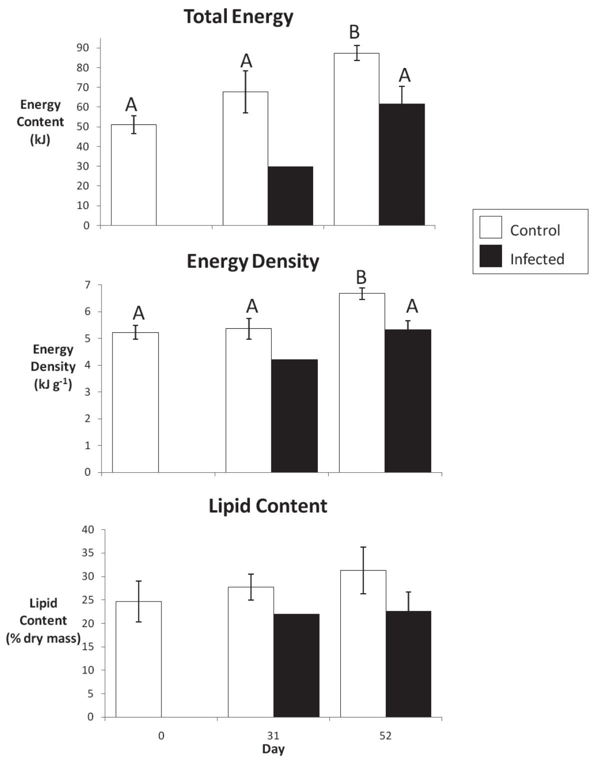


Figure 1. Energetic cost of *Ichthyophonus* infection in “autumn” young-of-the-year Pacific herring depicted by total energy content, energy density, and lipid content (% dry mass). Fish represented in this figure were cultured in ambient water temperature (9.5°). Different letters represent statistical differentiation. Lack of letters indicates no statistical differentiation. Low sample size of infected fish on day 31 precludes statistical tests.

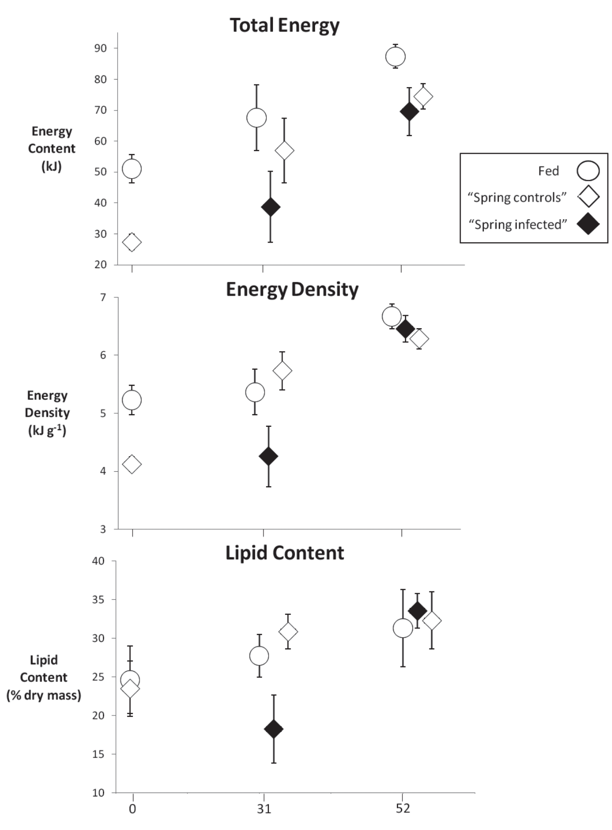


Figure 2. Compensatory response of young-of-the-year Pacific herring infected with *Ichthyophonus* depicted by total energy content, energy density, and lipid content (% dry mass). Fish represented in this figure were cultured in ambient water temperature (9.5°). Low sample size of infected fish on day 31 precludes statistical tests.

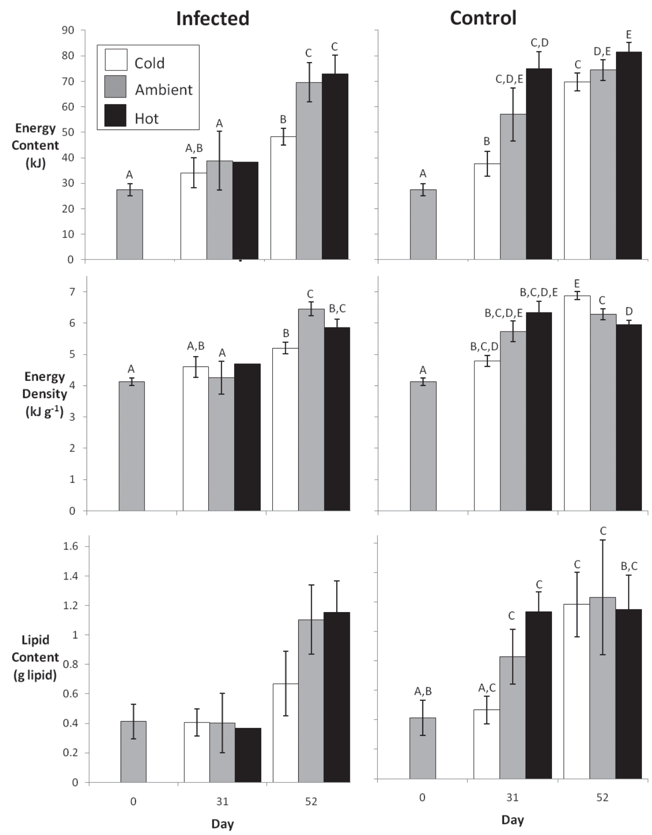


Figure 3. Temperature influence on the energetic cost of *Ichthyophonus* infection in “spring” young-of-the-year Pacific herring depicted by total energy content, energy density, and lipid content (g lipid). Water temperatures were cold (9.5°), ambient (12.0°), and hot (15.0°). Different letters within a panel represent statistical differentiation. Lack of letters indicates no statistical differentiation. Low sample size of infected fish on day 31 precludes statistical tests.

Alaska Fishery and Survey Data on the Web

Data from the AFSC's longline survey and groundfish catch from the NMFS Alaska Regional Office (AKRO) Catch Accounting System (CAS) and the North Pacific Groundfish Observer Program are now available online through the Pacific States Marine Fisheries Commission's Alaska Fisheries Information Network (AKFIN; https://akfinbi.psmfc.org/analytics). AKFIN's mission is to consolidate multiple fishery data sources so that mangers and scientists can access data efficiently and in formats specific to their needs. In cooperation with the Marine Ecology and Stock Assessment program (MESA) at ABL, the AKRO, and the Observer Program, AKFIN has developed reports that make the data sources we regularly use available in one central location. These reports were developed specifically to fit our data needs. Users of observer and longline survey data no longer need to use a special connection to access data, nor do they need to join tables to get, for instance, specimen and haul data in one data table. AKFIN works directly with managers of the CAS, the longline survey, and the observer databases to ensure up-to-date feeds. As new needs arise, reports can easily be adapted and created. To create an account for accessing these reports, contact Robert Ryznar at Robert_Ryznar@psmfc.org. Contact Cara Rodgveller with questions about the web-accessible reports (cara.rodgveller@noaa.gov, 907-789-6052).

By Cara Rodgveller

Sablefish Movement Analysis

James Murphy gave a presentation titled "Sex and Age-Specific Movements of Sablefish in Alaskan Waters" at the 2011 annual meeting of the American Fisheries Society in Seattle, Washington on 7 September. Sablefish have been tagged annually during longline surveys in the Gulf of Alaska, Aleutian Islands, and the slope of the eastern Bering Sea shelf since the late 1970s. Almost all tagged sablefish are captured by longline and trawl fisheries with a small number captured by research surveys. Most recoveries occur in Alaskan waters with some occurring in British Columbia and a few along the West Coast of the United States.

Murphy gave an overview of the ABL sablefish tagging program and presented preliminary results of ongoing movement modeling efforts. In 1991, ABL scientists Jon Heifetz and Jeff Fujioka published a sablefish movement model utilizing longline survey tagging data. Heifetz and Fujioka analyzed sablefish movement based on size-at-release, and Murphy's current analysis extended their work by adding sex and age-structure to the model. At time of tagging, the sex and age of the sablefish are not known, but these can be assigned by utilizing sex-specific length and age data collected during the surveys. Most sablefish recoveries are reported back to ABL without any sex data however; only those recoveries with sex information were utilized in the analysis.

Preliminary results indicate moderate to substantial differences in movement patterns between ages. Younger sablefish tend to move towards or remain in western areas of the Gulf of Alaska, while older sablefish tend to move towards or remain in eastern areas. Whether sex-specific differences in movements occur is uncertain and requires further analysis. These findings are similar to the length-based results of Heifetz and Fujioka but can be readily utilized in future spatial age-structured assessment models.

By James Murphy

Almost all tagged sablefish are captured by longline and trawl fisheries with a small number captured by research surveys.

2012 Research Projects Fulfill Specific Data Collection Needs

Each year approximately 300 fisheries observers collect a range of fisheries-dependent data aboard vessels targeting groundfish within the Alaskan Exclusive Economic Zone. To ensure data quality and consistency, these observers are trained, advised, and debriefed by the Fisheries Monitoring and Analysis (FMA) Division. Trained observers are deployed, on average, over 35,000 sea-days a year, thereby offering a unique opportunity to acquire data for special scientific research projects.

Observers have a standard workload to collect catch effort, catch composition, and biological information, which varies depending on the gear and vessel type of the observer's deployment. Current sampling protocols require observers to obtain multiple samples per fishing event, fully tasking observers and limiting their time for additional projects. Nonetheless, FMA recognizes that observers aboard fishing vessels and at processing facilities offer a unique opportunity to garner additional scientific information quickly and efficiently. To provide this additional service to the NMFS scientific community, FMA annually solicits proposals to conduct research projects (previously referred to as special projects) and obtain scientific collections from NMFS observers. These proposed projects typically address a need for information that requires 1-3 years of data or enable FMA to gradually develop and integrate a new high priority scope of work into the program. In this second case a project can be conducted by a few observers to evaluate the feasibility of collecting the required information at sea. Modifications can be made from year to year until a determination is made whether to fully implement the collection into the standard program or not

For the 2012 fishing year, two research projects were accepted. The first project, an Atka mackerel tag reporting rate study submitted by Principal Investigator Susanne McDermott, proposes to estimate the reporting rate of tagged Atka mackerel in the factories of catcher-processor trawlers during the Atka mackerel fishery in 2012. According to the proposal, tagged Atka mackerel were released in early summer 2011 in NMFS statistical areas 541 and 542, and most of the tag recovery effort will occur during two seasonal fisheries that open on or about 1 January and 1 June 2012. FMA recognizes the importance of knowing the proportion of tagged fish caught by the vessel that are actually recovered in the factory and reported to the observer. This project has been successfully conducted in previous years and will be assigned to observers on catcher/processor trawlers in the Aleutian Atka mackerel fishery beginning in January and ending in December 2012 .

The second research project accepted for 2012 is a coral bycatch identification and collection program submitted by Principal Investigator Robert Stone. The primary objective of this project is to improve observers' identification of the diverse coral fauna collected as bycatch in Alaskan groundfish fisheries. A second long-term objective is to improve our knowledge of the distribution and species richness of important coral taxa along the Aleutian Islands Archipelago. The FMA Division has a special interest in this project as we see the opportunity for improving the information we collect and provide to a broad suite of internal and external clients beyond those proposing this project. We have previously successfully improved species identifications of skates and grenadiers through a multi-step process involving research projects which we now plan to adopt for corals.

…FMA recognizes that observers aboard fishing vessels and at processing facilities offer a unique opportunity to garner additional scientific information quickly and efficiently.

In addition to the research projects that will be conducted in 2012, FMA will be incorporating a previous research project into our standard collection protocols for fishery observers in 2012. The Gulf of Alaska (GOA) skate age and maturity collection submitted by Principal Investigator Christopher Gburski was first implemented as a research project in 2006. The purpose of this study has been to collect information on age, growth, and maturity of the three most common species of skate in the GOA: big skate (*Raja binoculata*), longnose skate (*Raja rhina*), and Aleutian skate (*Bathyraja aleutica*). A directed fishery is targeting many species of skate in the GOA and it is imperative for fisheries managers to understand aspects of skate reproductive biology and development for stock assessment. This collection has been successfully completed by observers as a research project and will now be integrated as part of our standard collection protocols for fishery observers in the GOA.

Annual research projects can provide valuable data for a short-term project or test the feasibility of longer term standard data collections. FMA's annual call for research project proposals goes out in late spring and the deadline for proposal submission is 15 July.

By Patti Nelson

Alaska Ecosystems Program

Using Traditional Knowledge and Archived Documents to Aid Research and Conservation Goals for the Northern Fur Seal

In preparation for the Fur Seal Arbitration between the United States and Great Britain in 1892, the Secretary of the Treasury ordered C. L. Hooper, Captain of the steamer *Corwin*, to visit all the Aleutian passes east of the Islands of Four Mountains to document which passes the northern fur seal (*Callorhinus ursinus*) herd migrated through to enter the North Pacific Ocean. The expedition was to obtain affidavits from Aleut hunters detailing their knowledge of the movements of the seal herd after departing the Pribilof Islands and before appearing off the coast of western North America. The dispute between the two countries was over jurisdictional rights of the United States to restrict Great Britain from harvesting seals in pelagic waters, and information pertaining to fur seal migratory patterns was needed by the United States to present its "Counter Case" to the Tribunal of Arbitration. C. L Hooper's report to the Tribunal of Arbitration summarized what he learned during his trip to the Aleutian passes and several Aleut island communities during fall 1892 and emphasized the traditional knowledge communicated to him by the 80 Aleut hunters he interviewed.

The report described several elements of the fur seal winter migration including the timing of departure, distribution at sea of pups, juveniles, adult males, and females, and the effect of wind and currents on their migratory behavior. Specifically, Captain C. L. Hooper noted the following:

- Unimak Pass was the primary Aleutian pass chosen by fur seals because it was wider than the others and, thus, less subject to strong currents and tidal rips than the narrower passes. It was also thought that the majority of adult females, young males, and pups migrated to waters near western North America, whereas, adult males remained mainly in Alaskan waters during the entire winter.

Table 1. Adult male and female northern fur seal use of Aleutian passes during migrations from St. Paul Island, Alaska.

Aleutian Pass	Number of Fur Seals by Year and Sex 1992 M	2002 F	2004 F	2005 F	2006 F	2007 F	2008 F	2009 F	2009 M	Total
Unimak	2	12	14	12	5	4	7	8	1	65
Akutan		1		1	1			1		4
Umnak	1									1
Samalga	1		2	3			1		1	8
Yunaska				1					1	2
Amukta			1	2						3
Seguam			2		1					3
Amchitka									1	1
Murray Canyon	1								1	2
Medney/Aleutian Ridge	1									1
N of Commander Islands	1									1
Total	7	13	19	19	7	4	8	9	5	91

- Few seals traveled through the passes before 1 November and, by the end of December, the main body of the fur seal herd had left the Bering Sea. The timing of this varied from year to year and was dependent on the weather. An early approach of winter, for example, caused an early southward migration and the contrary was true for late winters.
- Fur seals always traveled with a fair wind and disliked traveling against the wind and sea; pups sought shelter among the Aleutian Islands during strong gales and traveled separately from adults; and, because of stormy conditions due to easterly gales in the North Pacific Ocean, it was evident that the seal herd made its way to waters near western North America without necessary delay after leaving the passes.

In the 1940s and 1950s, government officials who managed the fur seal harvest and scientists on the Pribilof Islands began to suspect variability in weather patterns affected survivorship of fur seal pups and the timing of the 3-year-old males' arrival at the Pribilof Islands. In a memo, written in 1941, U.S. Fish and Wildlife Service research scientists Banner and Wilke stated the importance of learning the effects of weather on the movement of seals and suggested comparing the arrival date of harvestable seals to weather and oceanographic data. More than 600,000 pups were flipper tagged on the Pribilof Islands in 1941-68 and, as a result, local beachcombers along the Pacific Northwest coast began to report stranded and dead flipper-tagged fur seal pups to wildlife biologists. In several cases, beachcombers wrote detailed letters stating that poor weather conditions preceded their finding of a dead or stranded pup and that the pup appeared emaciated. These letters contributed to Scheffer's (1950, California Fish and Game) publication describing an unusual stranding and mortality event associated with strong storms during the winter of 1949-50.

Today, the National Marine Mammal Laboratory's Alaska Ecosystems Program (AEP) and its collaborators (University of Alaska Fairbanks, Dalhousie University, University of Washington School of Oceanography, Joint Institute for the Study of the Atmosphere and Ocean, and University of Tasmania) have research goals that include quantifying several features of the northern fur seal migration described above. For example, the following research projects seek to understand how abiotic and biotic factors affect fur seal migration patterns either directly or indirectly with an emphasis on determining the effects of local conditions on movement and dive behavior.

- Consequences of Fur Seal Foraging Strategies, funded by the North Pacific Research Board;
- Northern Pinnipeds' Roles as Bioprobes, funded by the National Undersea Research Program;

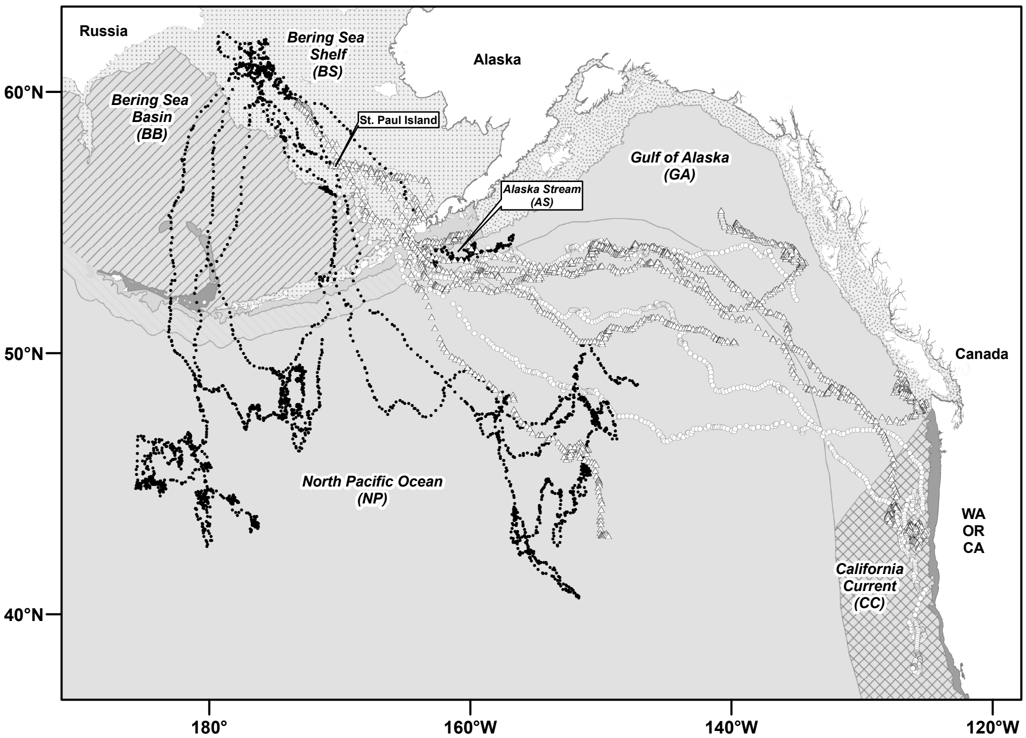


Figure 1. The migratory tracks of northern fur seals from St. Paul Island, Alaska, in 2009, overlaid on ecoregion designations. Five adult males were equipped with CTD-satellite-dive tags (black dots), six adult females with satellite-dive tags (white triangles), and four adult females with satellite tags only (white dots). These results are part of a collaborative study with the University of Alaska Fairbanks and Dalhousie University (Canada), funded by the National Undersea Research Program.

- Tempestuous Events and Migration Pathways—Effects on Survivorship and Transit, funded by NOAA's National Cooperative Research Program; and
- AEP's fur seal pup and adult satellite-tagging efforts.

The goal of identifying factors affecting fine-scale foraging patterns could also highlight conditions affecting overwinter survivorship. The approach ranges from describing broad-scale distribution patterns of each sex and age class to examining individual dive depths in relation to fine-scale biophysical measurements obtained from advanced oceanographic instruments.

Since 1991, 349 fur seal pups, juveniles, and adults have been equipped with a mixture of satellite-tag technology. These tags provided information on fur seal migratory routes, dive behavior and, in some cases, temperature, salinity, and depth data. Analytical methods utilized advanced animal movement models to identify movement behaviors, which were then spatially and temporally linked to remotely sensed fields, such as wind data, altimetry, sea-surface temperature, and surface chlorophyll *a* concentration. Other linkages included the proportion of daylight, fraction of the moon illuminated, and ecosystem (Fig. 1) where the behavior occurred.

Our recent findings support the traditional knowledge communicated to C. L. Hooper by the Aleut hunters over 119 years ago, while providing additional explanation about the biophysical factors influencing individual fur seal migratory behavior. The initial

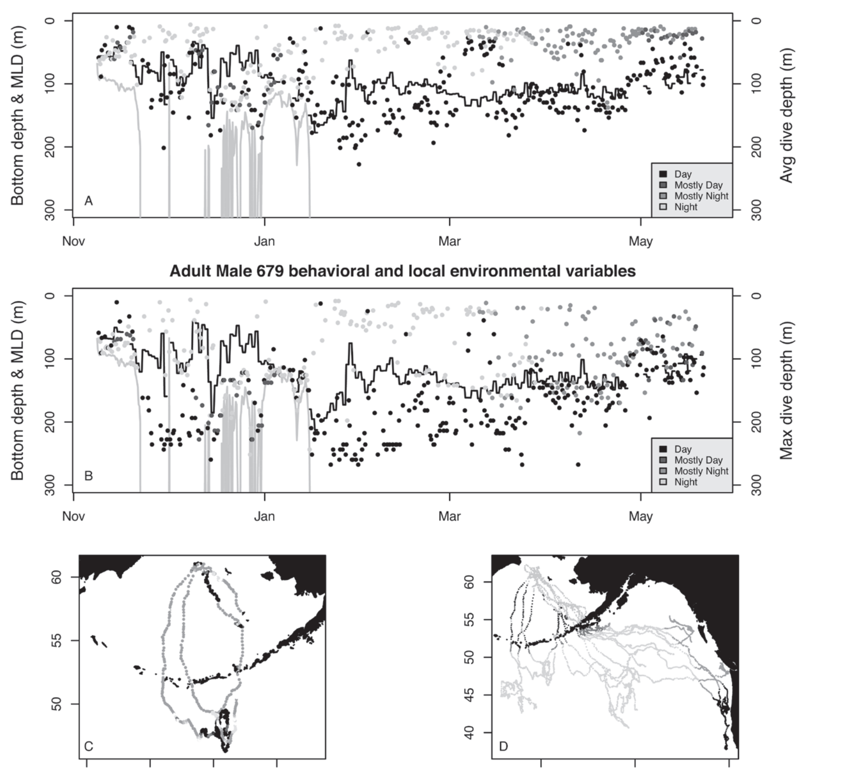


Figure 2. The dive and migratory behavior of adult male northern fur seal 679 in relation to horizontal and vertical oceanographic features. A) Average dive depth, and B) maximum dive depth at different times of day are plotted in relation to mixed-layer depth (MLD) (black line), determined by onboard temperature and salinity measurements, and bottom depth (gray line), while C) movement behavior is separated into searching (black dots) or traveling (gray dots)—in comparison to D) the migratory tracks of all northern fur seals tagged in 2009, highlighted for ecoregion (see Fig. 1).

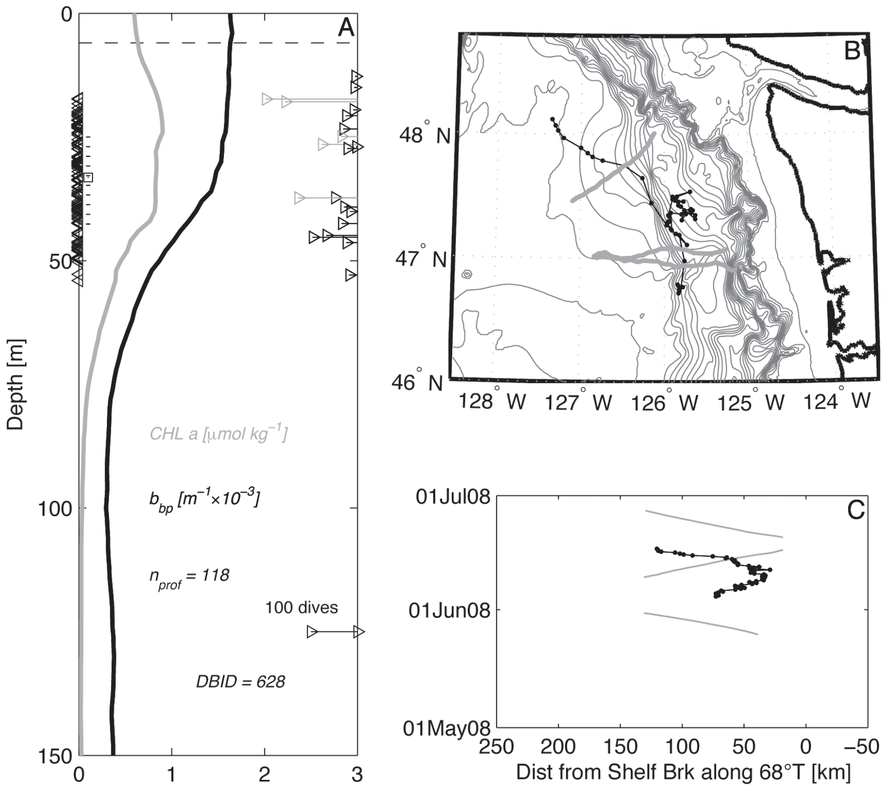


Figure 3. Fine-scale integration between the migratory dive behavior of an adult female northern fur seal and the Washington Coast Seaglider transect line (Eriksen Group, University of Washington School of Oceanography). A) Biophysical measurements taken by a Seaglider: black triangles on left y-axis (depth) indicate mixed-layer depth (MLD) calculations; gray line indicates chlorophyll a measurements; black line indicates backscatter measurements; triangles on right y-axis show average dive depth, colored by time of day dives occurred (gray = night, black = day), and length of attached line is scaled to number of averaged dives; B) location of female fur seal (black dots and line) and Seaglider transect line (gray lines); and C) distance from shelf break where dives occurred and dates when they intersected.

dispersal and movement patterns of pups departing St. Paul Island, Alaska, were influenced by high winds due to Arctic storms, while over 70% of the adults traveled through Unimak Pass to enter the North Pacific Ocean (Table 1). Adult males remained in the North Pacific Ocean or Bering Sea during the winter, while adult females transited quickly to the Gulf of Alaska and California Current ecosystems and the Transitional Zone Chlorophyll Front (Fig. 1). Temperature and salinity measurements recorded by onboard CTD-satellite-dive tags and the Washington Coast Seaglider survey line show the interplay between the mixed-layer depth (MLD) and fur seal dive behavior (Figs. 2 and 3); most daytime dives occurred at or below the MLD and nighttime dives above it, highlighting the behavior of the fur seals' preferred prey. Most adults and pups start their migration in November, and, by January, the majority of adults and to a lesser extent pups have exited the Bering Sea and entered the North Pacific Ocean (Fig. 4). Finally, pup movement behaviors, both swim speed and direction, during their first month at sea were coupled to wind speed and direction, with tailwinds coinciding with the direction of travel enabling greater swim speeds.

With the aid of new microtechnologies, oceanographic quality sensors, and access to remotely sensed satellite data for environmental parameters in the North Pacific Ocean, we are now able to reconstruct some of the observations and theories that Aleut hunters, C. L. Hooper, and wildlife biologists intrinsically knew from their observations as far back as 1892 (and before). With continuing analyses, we hope to elucidate the links between atmospheric and marine variability and the survival of northern fur seals.

By Jeremy Sterling

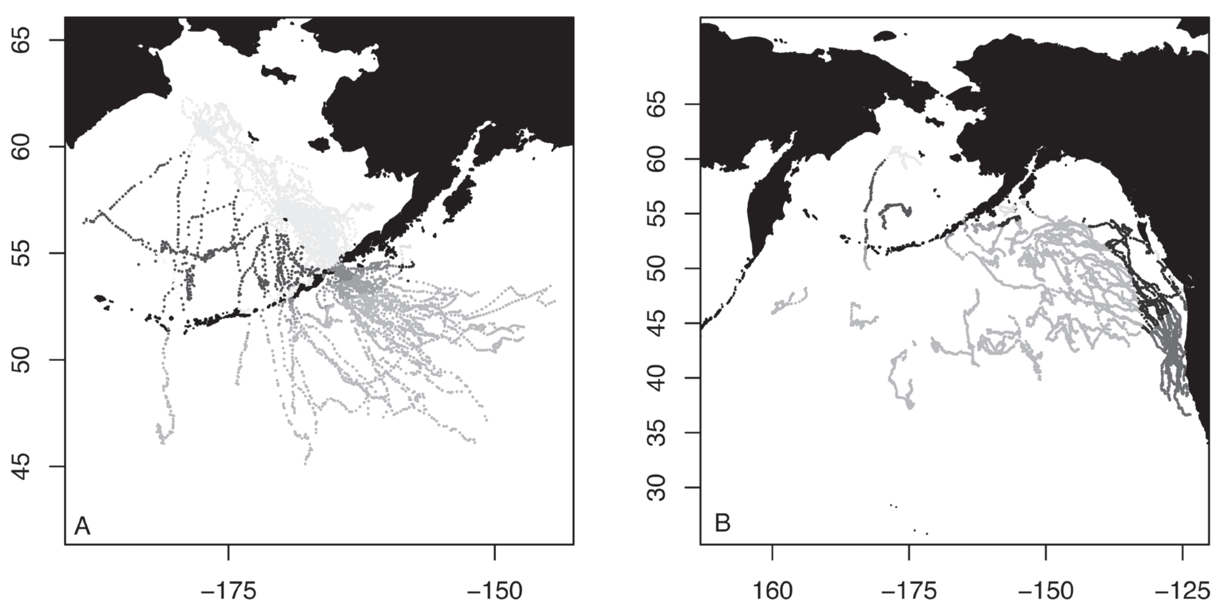


Figure 4. Distribution plots highlighted by the ecoregion (see Fig. 1) of adult fur seals departing St. Paul Island, Alaska, in A) November, and B) January.

Cetacean Assessment & Ecology Program

Finding the Needle in the Haystack: Using Sonobuoys to Locate a Critically Endangered Species

The National Marine Mammal Laboratory's (NMML) Cetacean Assessment and Ecology Program (CAEP) has been conducting large-scale marine mammal surveys for many years, and the inclusion of passive acoustics has become an increasingly vital component. Since 2007, CAEP acousticians have been deploying both long-term recorders and short-term instruments called sonobuoys to acoustically detect and monitor whale populations. Designed for military purposes, sonobuoys are free-floating, expendable, short-term hydrophones that transmit signals in real time via VHF radio waves to a receiver on a vessel (or aircraft). Acoustic detection ranges are highly dependent on water propagation conditions, but typically average 10-15 nautical miles (nmi), allowing for greater coverage than visual surveys alone.

Because they contain batteries, sonobuoys have a limited shelf life. The military is often unable to use all of their sonobuoys before the expiration date. Because their operations have no room for equipment failure, expired sonobuoys are sent to surplus, where many are donated to marine mammal scientists for passive acoustic research. Sonobuoys come in two main types: omnidirectional sonobuoys can record up to 100 kHz, a frequency range that includes most marine mammal vocalizations. DiFAR (Directional Frequency Analysis and Recording) sonobuoys can only record up to 2.5 kHz, which is still sufficient for most vocalizations, but they transmit directional bearing information in addition to the acoustic signals.

By deploying two or more sonobuoys separated by a few miles, we can obtain a cross-fix on a calling whale and localize on the whale's position in real time.

By deploying two or more sonobuoys separated by a few miles, we can obtain a cross-fix on a calling whale and localize on the whale's position in real time. Usually this is done to verify that the calling whale is the same individual spotted by the observers and to conduct focal follows to correlate acoustic behavior with surface and dive patterns. On occasion, however, this directional information becomes much more important.

North Pacific right whales (*Eubalaena japonica*) are arguably one of the most endangered marine mammals in the world (Fig. 5). Current estimates put the size of this population at fewer than 40 individuals, which makes them difficult to locate in even the best conditions. In thick fog and high sea states (common in the southeast Bering Sea), it becomes nearly impossible to visually spot a right whale. However, the use of sonobuoys and the ability to localize on a calling whale dramatically increase the odds of finding these extremely rare animals.

Figure 5. North Pacific right whale (NMML #27, "Blip"), NMML Permit #172-1719. Photo by Amy Kennedy.

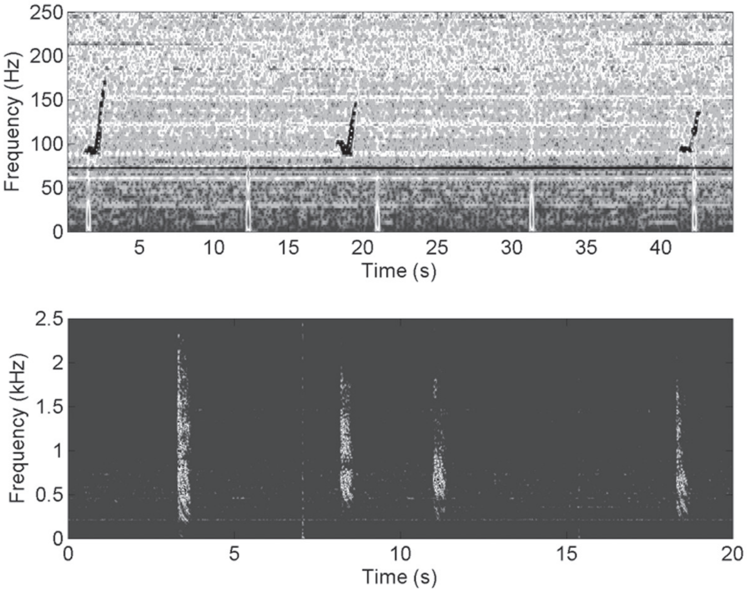


Figure 6. Spectrogram of the upsweep (top) and gunshot (bottom) calls produced by the North Pacific right whale.

Figure 7. Deploying a sonobuoy from the rail of the NOAA ship *Oscar Dyson*.

Right whales produce two distinct and easily identifiable vocalizations, the upsweep and the gunshot call (Fig. 6). The upsweep call, with a frequency range of 80-250 Hz, can sometimes be confused with a humpback call. However, humpbacks tend to produce many other varying calls in conjunction with the upsweep, whereas, the upsweep of a right whale typically stands alone. Thus, right whales can often be distinguished from humpbacks by looking at the call in the context of other vocalizations around it. The gunshot call, as the name implies, is a distinctive short, impulsive, broadband sound. By localizing on these two call types, acoustic technicians can direct the boat to within sighting distance of the calling whale.

After a successful 2008 field season using sonobuoys (Fig. 7), passive acoustic monitoring was incorporated into the right whale aerial survey as well. Sonobuoys were deployed from the belly port of the aircraft (Fig. 8), and all receiving equipment was secured to a board that hung on the back of a seat. Because the sonobuoys rely on line-of-sight from the float to the antenna for signal transmission, the aircraft was able to obtain far greater reception ranges than the vessel, which was limited to 10-15 nmi. Right whales were detected by aerial observers on over 55% of the sonobuoys deployed from the aircraft, increasing the overall number of sightings.

Due to their efficiency in detecting calling whales in limited visibility and high sea states, both the aerial and vessel surveys were able to locate right whales more quickly, allowing for more time with the animals and a more productive survey. The right whale project no longer conducts large-scale surveys and, as a result of budget cuts, is limited to only a handful of days piggybacking on transits of other project cruises. Finding right whales quickly is now critical, and using sonobuoys provides the best chance of maximizing the time available with the animals.

Since 2007, over 1,000 sonobuoys have been deployed throughout the Bering, Chukchi, and Beaufort Seas, and they have detected at least nine different cetacean species. The inclusion of sonobuoys not only increases the coverage area of a survey and the number of sightings but also allows us to continue to monitor critically endangered populations even in limited visibility and high sea states.

NMML would like to thank Jeff Leonhard (Naval Surface Warfare Center, Crane Division), Theresa Yost (Naval Operational Logistics Support Center), Todd Mequet (Applied Logistics Services, Inc.), and Captain Robin Fitch (Director of Marine Resources and At-Sea Policy, Office of the Assistant Secretary of the Navy, Installations and Environment) for their continued support in providing us with sonobuoys.

By Jessica Crance

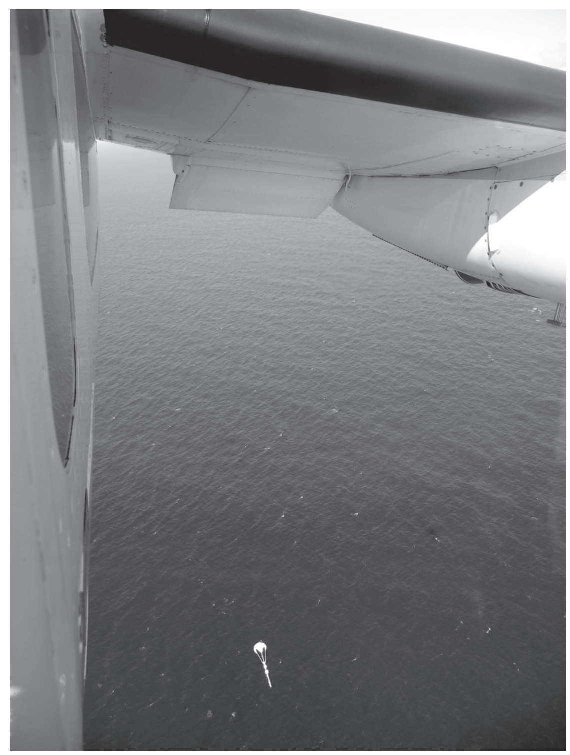


Figure 8. A sonobuoy being dropped from the belly port of the Aerocommander during the 2009 right whale aerial survey.
Photo by Jeff Foster.

Polar Ecosystems Program

Researchers from the Polar Ecosystems Program Census Harbor Seals Along Coastal Alaska

The NMML's Polar Ecosystems Program (PEP) is responsible for monitoring and estimating the abundance, trends, and distribution of harbor seal populations in Alaska, which range from Southeast Alaska through the extent of the Aleutian Islands and north into Bristol Bay. The PEP conducts aerial surveys of harbor seals every July and August. This is one of the largest regularly occurring wildlife surveys in the world. The 2011 surveys ranged from Attu Island (172°E) in the western Aleutian Islands to Portland Canal (130°W) in Southeast Alaska—a straight-line distance of approximately 2,000 nmi and roughly 4,000 nmi of coastline (20,000+ nmi of tidal shoreline) (Fig. 9). We utilized six aircraft, including three NOAA DHC-Twin Otters and three single-engine floatplanes from local charter companies. The scientific crew consisted of PEP scientists and support personnel from NOAA's Aircraft Operations Center.

This is one of the largest regularly occurring wildlife surveys in the world.

Survey sites are prioritized each year by incorporating 12 genetically distinct harbor seal stocks, named according to their general location: Aleutian Islands, Pribilof Islands, Bristol Bay, North Kodiak, South Kodiak, Prince William Sound, Cook Inlet/Shelikof, Glacier Bay/Icy Strait, Lynn Canal/Stephens, Sitka/Chatham, Dixon/Cape Decision, and Clarence Strait. Our survey efforts focus on sites that make up a significant portion of each stock's population; less significant sites (i.e., zero or low numbers observed in the past) are flown every 3 to 5 years to ensure that new haul-out sites or redistributions of seals are incorporated into the surveys. Seals on shore are surveyed within a 2-3 hour period, scheduled to coincide with local low tide. (See Figs. 10 and 11 for 2011 survey efforts in the Gulf of Alaska and Southeast Alaska.)

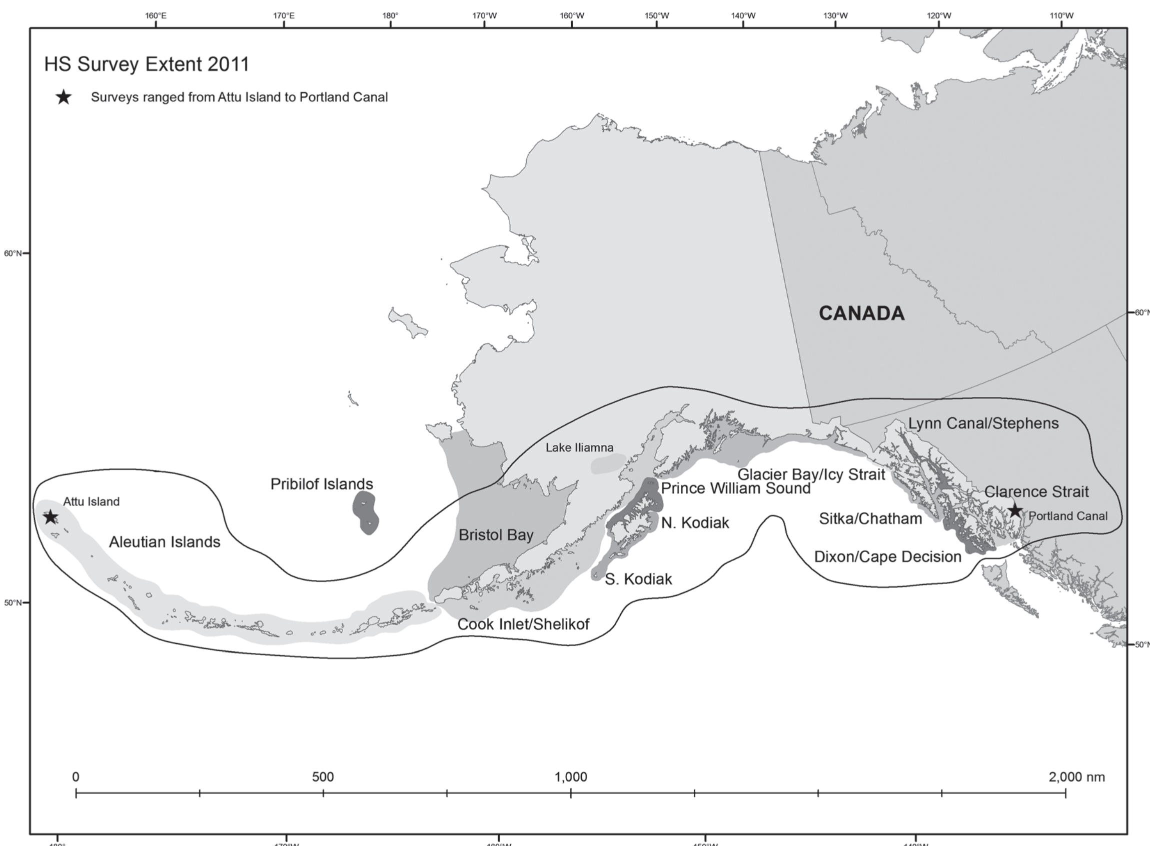


Figure 9. Harbor seal survey extent in 2011. Genetically distinct stocks are labeled and the black line indicates the survey area of approximately 4,000 nmi of coastline.

The 2011 surveys also included efforts to monitor the population and trends of harbor seals that rely on tidewater glacier habitats, which support the largest known aggregations of this species in the world (e.g., >5,000 seals in Icy Bay). Biologists photographed seals hauled out on ice in tidewater glacial fjords using a three-camera, forward-motion-compensating camera system mounted in the belly port of a NOAA DHC-Twin Otter. Seals in these fjords are scattered across often enormous fields of floating ice that shift with currents, making the seals particularly difficult to count. Fjords with larger ice fields are photo-sampled along transects, and seal distributions are estimated using spatial models. Methods developed in 2010, of creating mosaics to get complete counts of smaller fjords, were tested again with positive results. Tidewater-glacier habitat surveys are timed to overlap with the peak abundance of seals hauled out on ice, which typically occurs between 1300 and 1700 hours. Glacial fjords surveyed in 2011 included Icy and Disenchantment Bays in the Gulf of Alaska; Tracy Arm, Endicott Arm, and LeConte Bay in Southeast Alaska; and College Fjord, Barry Glacier, and Bering Glacier in the Prince William Sound area. Most of the glaciers surveyed are in a phase of rapid retreat, which paradoxically increases the area of calved ice and habitat for seals while getting closer to the point where the glacier will ground and no longer provide habitat for seals, as has already occurred in Glacier Bay and elsewhere.

Images collected in both terrestrial and tidewater glacier habitats are geo-referenced and counted. Counts are adjusted to account for seals that are in the water (i.e., not hauled out on land or ice), which provides us with the necessary data to estimate total abundance of the harbor seal population on an annual basis.

*By Erin Richmond,
Josh London, and John Jansen*

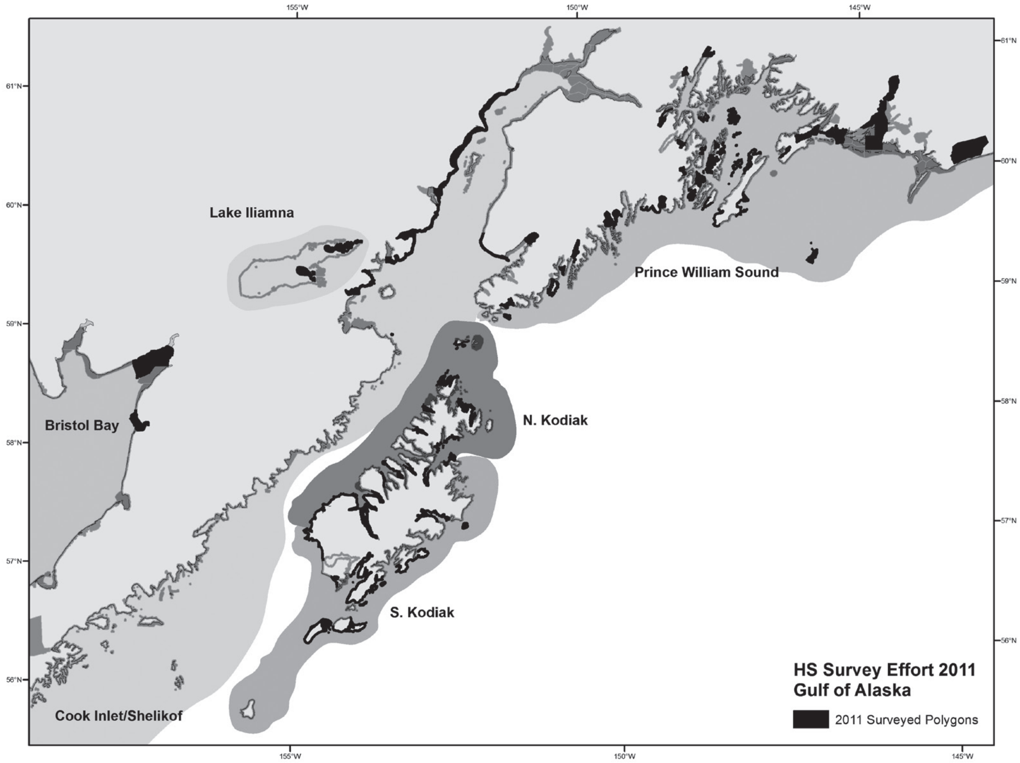


Figure 10. Harbor seal survey effort for the Gulf of Alaska in 2011.

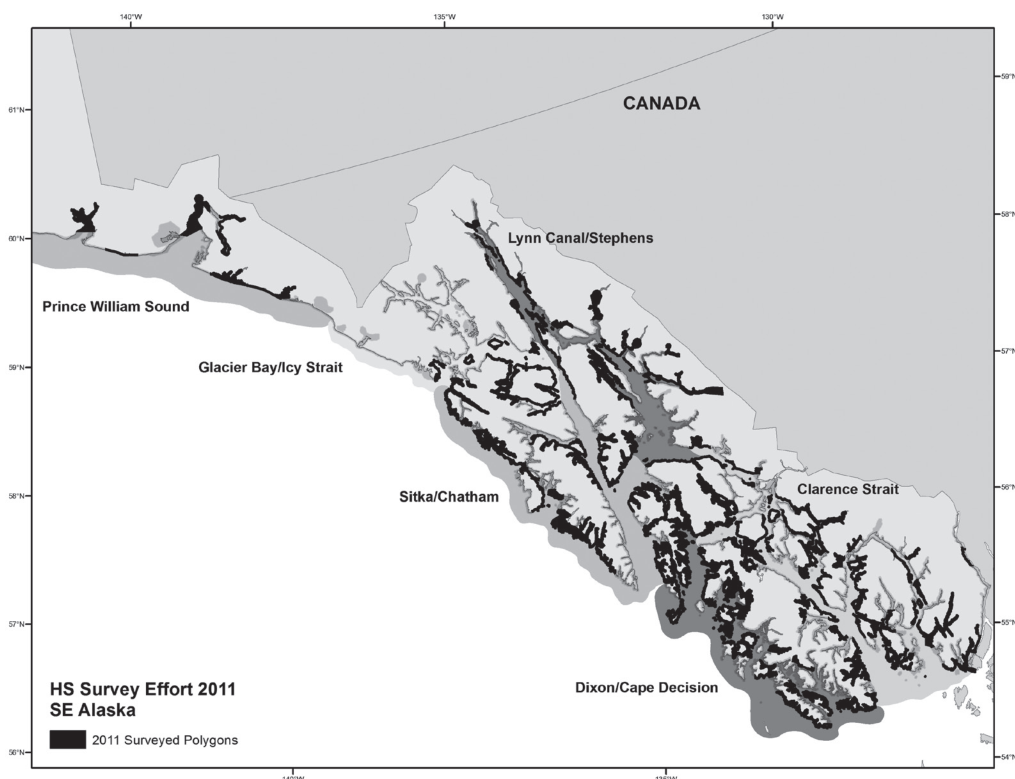


Figure 11. Harbor seal survey effort for Southeast Alaska in 2011.

Groundfish & Shellfish Assessment Programs

AFSC-Industry Cooperative Survey of Red King Crab in Nearshore Areas of Bristol Bay

RACE Division scientists Elizabeth Chilton and Dave Somerton (Fig. 1) participated in a special assessment of red king crab in the nearshore areas of Bristol Bay in cooperation with Alaska Department of Fish and Game (ADF&G) scientists Stacy Johnson-Mestre and Trent Hartill and with Scott Goodman of Natural Resources Consultants, Inc., representing the Bering Sea Fisheries Research Foundation (BSFRF). This study, funded by the BSFRF and the NMFS National Cooperative Research Program, was motivated by the observation that Bristol Bay red king crab distribution is correlated with water temperatures in the eastern Bering Sea, with crabs migrating from cold water areas of the Bristol Bay shelf into nearshore areas with warmer waters. One potential explanation for this phenomenon is that red king crab females perform an offshore migration to release larvae and find mates, which is delayed during years with colder water temperatures due to a delay in the crab larvae development. The result would be that some portion of the mature crabs remains near shore and outside of the established survey area, affecting the availability of these crabs to the standard bottom trawl survey.

The survey was conducted aboard the chartered commercial fishing vessel *American Eagle* working in conjunction with the 2011 AFSC eastern Bering Sea (EBS) bottom trawl survey. The BSFRF trawl operations were of shorter duration tows (5-8 minutes) at established survey stations using a Nephrops trawl (designed to capture nearly all epibenthos in its path) for comparison to 30-minute tows with the standard 83-112 eastern otter trawl used on the EBS survey. Nine nearshore stations along the Alaska Peninsula were added to the standard EBS survey in depths ranging from 25 to 35 m while the *American Eagle* completed 93 tows in areas shallower than those sampled by the EBS bottom trawl survey (Fig. 2).

The sampling objectives of this research project were met by successfully coordinating the completion of bottom tows using the Nephrops trawl gear in the nearshore area of Bristol Bay as well as in the standard EBS survey area, sampling both juvenile and adult red king crab with both types of trawl gear. The final objective of comparing red king crab population abundance and distribution estimated from this survey to the red king crab abundance and distribution estimated from the AFSC standard bottom trawl survey are currently being conducted.

By Elizabeth Chilton and David Somerton

Figure 1. Elizabeth Chilton and Dave Somerton sampling red king crab aboard the *American Eagle*.

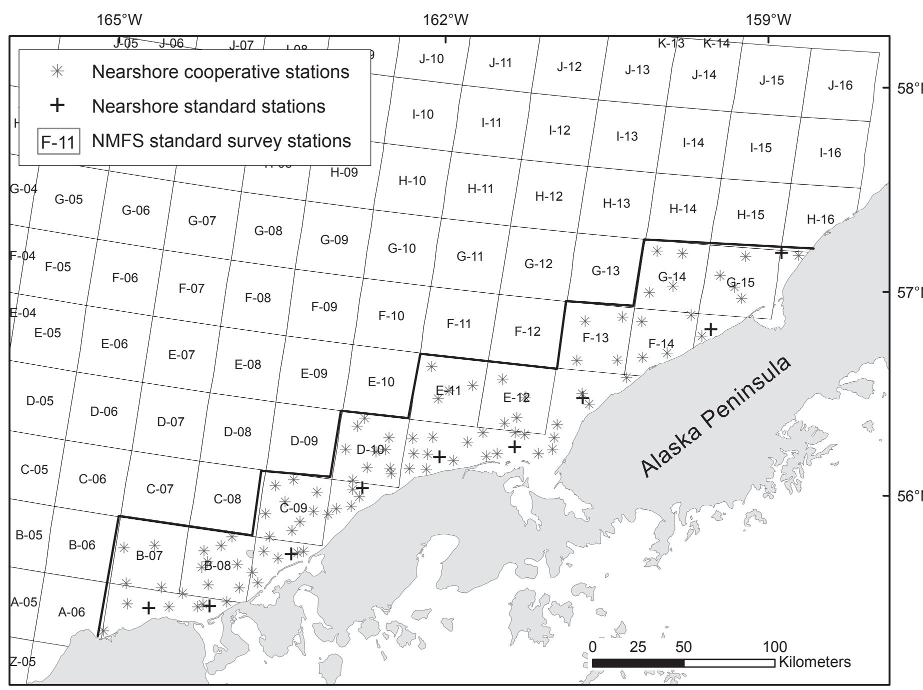


Figure 2. Locations of the AFSC eastern Bering Sea survey stations and stations sampled as part of the cooperative nearshore red king crab survey. The standard and nearshore survey stations included in the cooperative nearshore research area are outlined in black.

Thirtieth Annual Eastern Bering Sea Continental Shelf Bottom Trawl Survey

The summer of 2011 marked the 30th in a time series of annual standard bottom trawl surveys which are an integral part of managing and sustaining commercial fish and crab populations in the Bering Sea. From 1 June to 5 August 2011, scientists from the AFSC, ADF&G, International Pacific Halibut Commission, and University of Washington participated in the eastern Bering Sea continental shelf bottom trawl survey aboard the chartered fishing vessels *Aldebaran* and *Alaska Knight,* which conducted scientific bottom trawling operations at 376 stations over a standard survey area covering 143,705 square nautical miles (Fig. 3).

The science crew processed and recorded the catch from each trawl catch by identifying, sorting, and weighing all the different crab and groundfish species and then measuring samples of each species. At the conclusion of the survey, scientists carefully validated the data collected on fishing effort, catch rates, and biological characteristics of the fish and crab populations (e.g., size distribution, age, growth rates, diet, etc.) in preparation to generate fishery-independent estimates of geographic and depth distribution, population size and biomass, and age composition of the various species. Supplementary biological and oceanographic data collected on the bottom trawl survey will improve the understanding of life history for groundfish and crab species and the ecological and physical factors affecting their distribution and abundance

The "Cold Pool"

Depending on the extent and timing of seasonal ice cover over the eastern Bering Sea shelf, water temperatures can vary widely from year to year (Fig. 4) and have an effect on the distribution of groundfish and crab species. In 2011, scientists found that the mean bottom temperatures for individual stations ranged from -1.6° to 6.5°C and the mean bottom temperature for the entire eastern Bering Sea shelf (2.47°C) increased to a level slightly above the long-term mean bottom temperature (2.44°C) for the first time since 2005 (Fig. 4). The 2011 increase in mean bottom temperature corresponded to a 25%-50% reduction in the area of the cold bottom layer of water (< 2°C) called the "cold pool" compared to the last 5 years (Fig. 5).

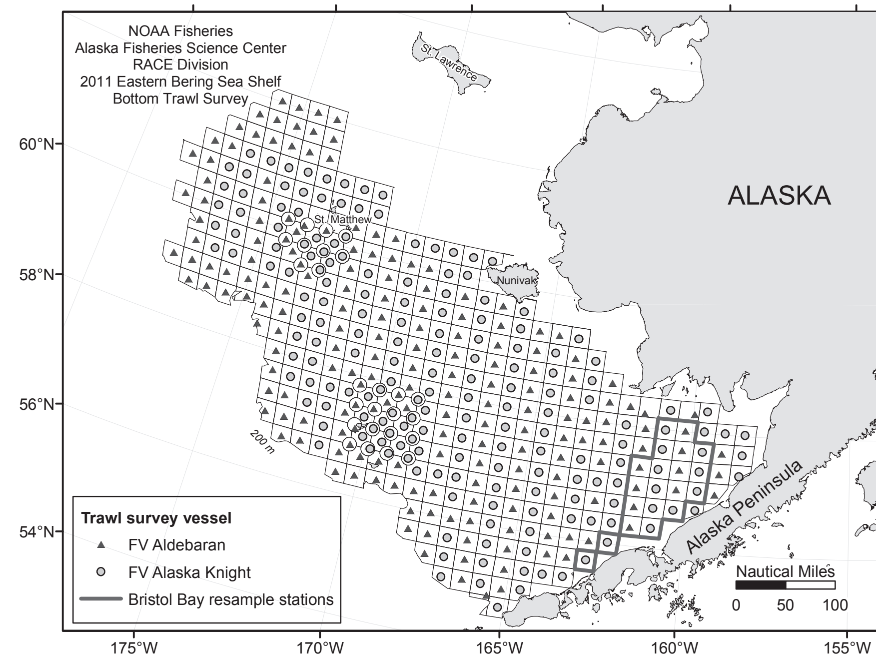


Figure 3. Sampled survey stations by vessel for the 2011 eastern Bering Sea shelf bottom trawl survey.

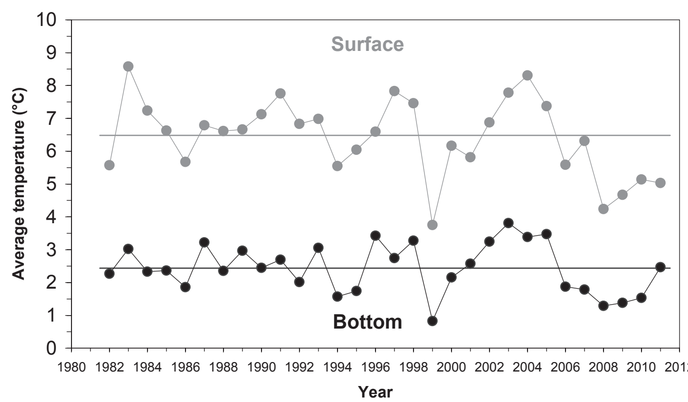


Figure 4. Time series of mean surface and bottom temperatures from the eastern Bering Sea shelf bottom trawl survey since 1982. Horizontal lines represent the mean temperature for years 1982-2010.

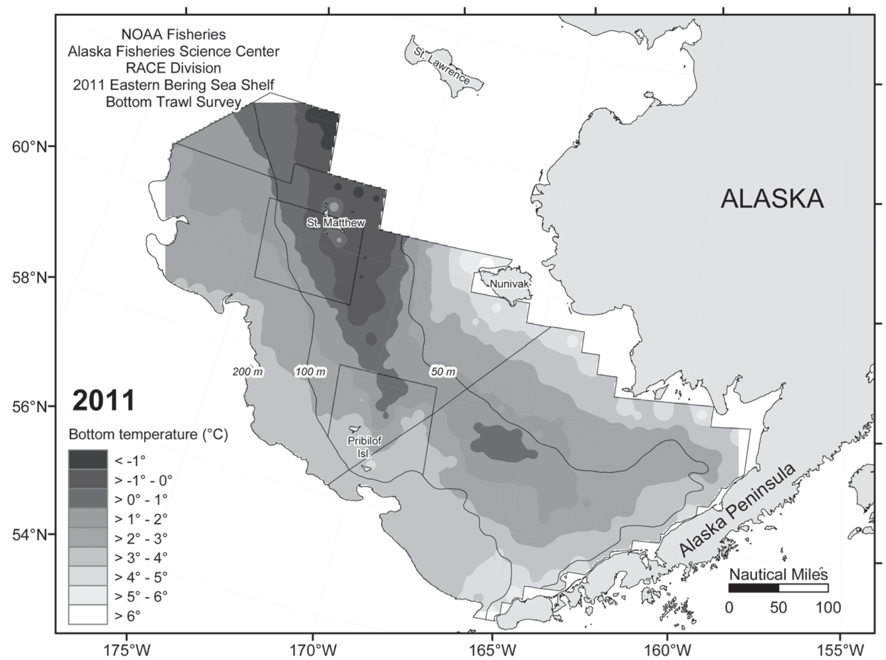


Figure 5. Distribution of bottom water temperatures (°C) observed during the 2011 eastern Bering Sea shelf bottom trawl survey.

Commercial Crab

In 2011, commercially important crab were caught at all but 23 of the standard stations (Fig. 6). Biomass estimates in metric tons of Bristol Bay legal male red king crab (*Paralithodes camtschaticus*) have decreased over the last 4 years from 33,541 metric tons (t) in 2007 to 15,412 t in 2011; mature males decreased from 30,248 t in 2010 to 19,599 t in 2011. Mature females in Bristol Bay decreased between 2010 and 2011 from 40,797 to 37,486 t. Estimates for legal males in the Pribilof District increased between 2010 (2,881 t) and 2011 (3,751 t); mature males also increased during this time from 3,107 t to 3,834 t, and mature female estimates increased from 468 t in 2010 to 814 t in 2011. The 2011 coefficients of variance (CV) of Bristol Bay mature male and female red king crab biomass estimates ranged from 15% to 25%; the Pribilof District mature male and female red king crab CVs ranged from 64% to 73%.

From 2010 to 2011, the estimated biomass of legal male blue king crab (*P. platypus*) in the Pribilof District increased from 202 to 399 t, and mature males increased from 322 to 461 t, with a CV for mature and legal males of 84%–88%. In the St. Matthew Island Section of the Northern District, both mature and legal-sized males increased from 2010 estimates of 8,141 and 4,317 t to 9,516 and 5,701 t, respectively, above the average estimates from the previous 20 years. The CV for the St. Matthew Island Section mature male biomass was 55%.

Mature male Tanner crab (*Chionoecetes bairdi*) abundance increased between 2010 and 2011 from 27,949 to 33,810 t; mature females also increased from 5,922 to 8,457 t. Abundance estimate of legal males increased from 7,955 to 14,229 t. The CVs for mature female and male biomass ranged from 8% to 26%.

Estimated biomass of legal male snow crab (*C. opilio*) increased from 136,140 to 146,275 t between 2010 and 2011 with a CV of 11%. Mature female biomass also increased from 132,166 t in 2010 to 236,886 t in 2011, with a CV of 18%.

The 2011 biomass estimates reported in metric tons (t) and pounds (lbs) with 95% confidence intervals (± 1.96 SE) for legal-sized males of commercial crab stocks in the eastern Bering Sea were as follows:

Commercial Crab Species	2011 Legal-sized Male Biomass (± 95% CI)	
Bristol Bay District red king crab (*Paralithodes camtschaticus*)	15,412 (5,238) t	33,977,299.61 (11,547,788.81) lbs
Pribilof District red king crab (*P. camtschaticus*)	3,751 (4,787) t	8,269,046.58 (10,554,038.49) lbs
Pribilof District blue king crab (*P. platypus*)	399 (693) t	879,573.20 (1,528,179.24) lbs
St. Matthew Island Section blue king crab (*P. platypus*)	5,788 (5,555) t	12,759,351.83 (12,246,469.72) lbs
Southern Tanner crab (*Chionoecetes bairdi*), east 166° W	10,207 (5,880) t	22,503,103.69 (12,964,143.55) lbs
Southern Tanner crab, east 166° W ≥ 5.5 inches	5,356 (4,344) t	11,807,249.93 (10,109,706.61) lbs
Southern Tanner crab, west 166° W	23,278 (16,729) t	51,319,174.78 (36,880,898.03) lbs
Southern Tanner crab, west 166° W ≥ 5.0 inches	15,676 (13,672) t	34,560,932.62 (35,029,759.51) lbs
Snow crab, all Districts (*C. opilio*)	146,297 (32,652) t	322,525,931.00 (71,984,466.52) lbs
Snow crab, all Districts ≥ 4.0 inches	94,763 (22,025) t	208,915,452.54 (48,556,399.29) lbs

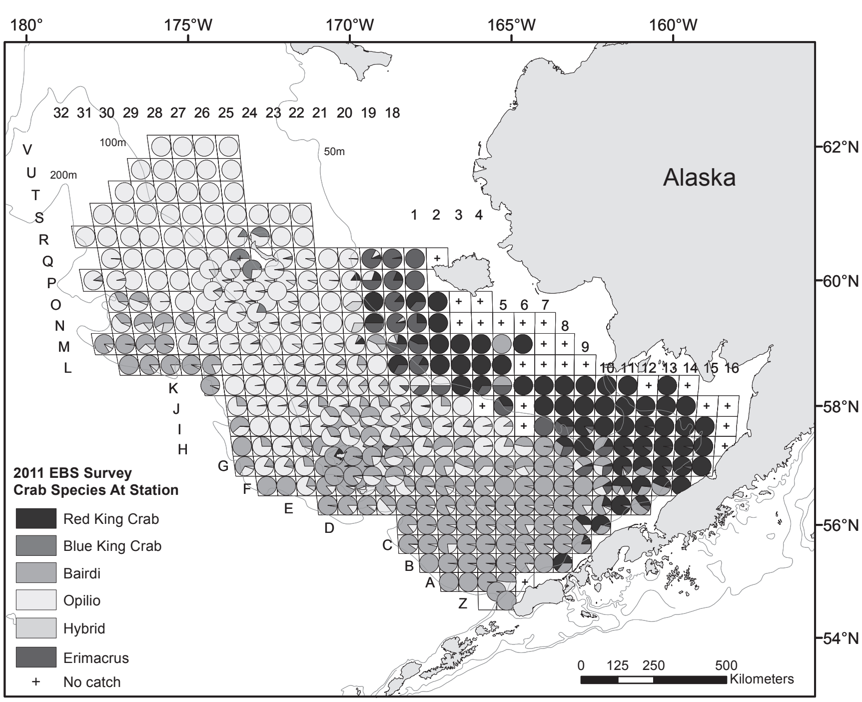


Figure 6. The 2011 eastern Bering Sea bottom trawl survey commercial crab species distribution at each station.

Due to the delaying effects of colder than average water temperatures on the red king crab reproductive cycle, the *Aldebaran* and *Alaska Knight* returned to Bristol Bay to resample 20 predetermined stations between 25 and 31 July. Stock assessment models rely on growth increments and mating success, and only 52% of the 450 mature females sampled during the standard survey had extruded a new clutch of uneyed embryos. Among resurveyed female crab in late July, 93% were mature females and of these, 94% were in new hardshell condition with newly extruded uneyed embryos. These new hardshell females had molted and mated over the 6-week period between the first sampling event in early June and the resample in late July.

Complete crab survey results from the EBS bottom trawl survey can be found on the AFSC website at http://www.afsc.noaa.gov/Kodiak/shellfish/crabEBS/2011EBSSurveyTechMemoDraft.pdf

Crab Special Projects – In addition to the standard data collection, several special projects were carried out during the survey, including the collection of live red king crab females sent to the AFSC's Kodiak Laboratory to study the effects of ocean acidification on reproductive success as well as larval condition and survival. Stomach samples from over 200 male and female *Chionoecetes* spp. were collected to investigate the diet of Tanner and snow crab. One hundred male snow crab were collected to study the effect of cold temperatures on crab metabolism and reflexes. Hemolymph samples from *Paralithodes*, *Hyas*, *Pagurus*, and *Elassochirus* spp., and *Erimacrus isenbeckii* were collected at randomly selected stations to monitor bitter crab syndrome and for population genetics studies; photographic and genetic data were collected from *Chionoecetes* hybrid crab. Nine survey stations were added to the standard survey design to assess adult and juvenile red king crab distribution in the nearshore waters of Bristol Bay.

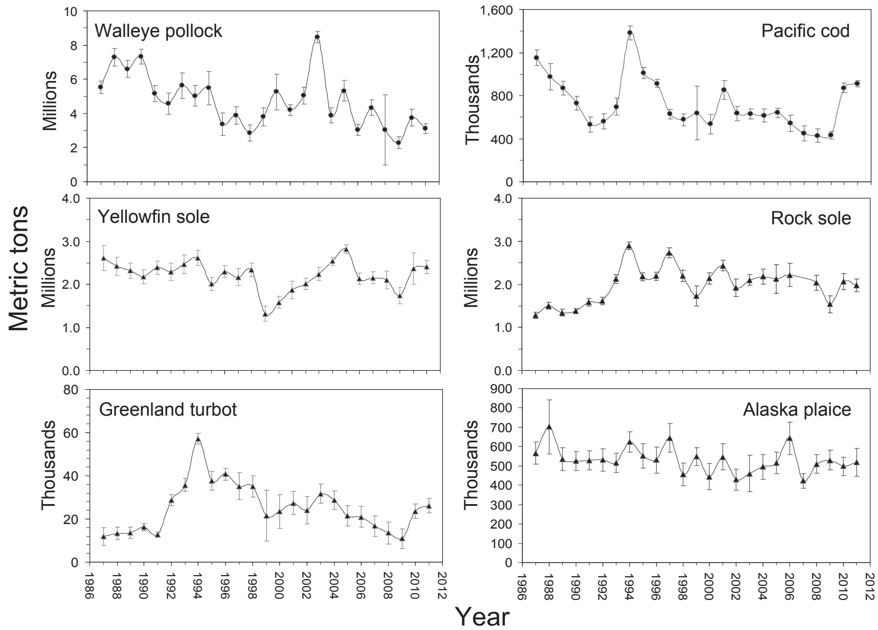


Figure 7. Time series (1987-2011) of estimated bottom trawl survey biomass for six eastern Bering Sea shelf groundfish species. Bars on data points are the standard errors for point estimates.

Groundfish

Data collections for groundfish from the EBS shelf trawl survey included 178,238 individual length measurements representing 46 fish taxa; 8,637 age structures representing 10 fish taxa; 5,150 stomach samples representing 4 fish taxa; and 1,622 pathobiology samples from 35 different fish and invertebrate taxa.

Trends in the annual estimates of bottom trawl survey biomass for selected groundfish species on the eastern Bering Sea shelf from 1987 to 2011 are shown in Figure 7. Compared to 2010, there were slight decreases in the survey biomass of walleye pollock and rock sole, and slight increases in the survey biomass for the other four species (Fig. 7).

- Walleye pollock: 3.11 million t
- Rock sole: 1.98 million t
- Alaska plaice: 520,000 t
- Greenland turbot: 26,200 t
- Pacific cod: 911,000 t
- Yellowfin sole: 2.40 million t

Visit http://www.afsc.noaa.gov/RACE/groundfish/survey_data/default.htm for current maps showing the spatial distribution and abundance of other fishes and marine fauna captured during the 2011 Bering Sea shelf bottom trawl survey and for shelf surveys dating back to 1982.

The NPFMC Groundfish Plan Team will begin their review and incorporation of the survey data in the scientific stock assessments at their 14-18 November 2011 meeting and will provide reports to the Council's Scientific and Statistical Committee (SSC). The SSC will recommend acceptable biological catch for the different species at the December Council meeting in Anchorage. The Council's Advisory Panel will then recommend a total allowable catch for each of the species. Following the committee reports, the Council will consider committee recommendations and public testimony before recommending a total allowable catch for the various groundfish species in 2012.

By Bob Lauth and Jan Haaga

Reproductive Biology of Pacific Ocean Perch, *Sebastes alutus*, in the Gulf of Alaska

Pacific ocean perch are the most abundant rockfish in the Gulf of Alaska and the most commercially important rockfish in this region. The stock assessment of this species in the Gulf of Alaska utilizes an age-structured model as the primary assessment tool. This model incorporates maturity estimates which directly influence the estimation of stock biomass and a very small change in this parameter can have a significant impact on the determination of total allowable catch. Therefore, it is critical to have accurate and up to date data on the reproductive parameters of this rockfish species. The values for age and length at maturity of this species currently utilized in the stock assessment are derived from a study predominantly employing visual techniques to assess maturity status and oocyte development. The objective of this study was to update and re-examine the reproductive biology of this species utilizing histological techniques to examine the seasonality and length and age at maturity of this species within the Gulf of Alaska.

Pacific ocean perch samples were collected opportunistically throughout the year during AFSC and ADF&G scientific surveys, from the North Pacific Groundfish Observer program, and from dedicated charters on the fishing vessel *Goldrush*. Samples were collected predominately from the central Gulf of Alaska, but some samples were taken from both the eastern and western Gulf, particularly in the late summer months. Fish lengths, weights, and ovary weights were measured and ovarian and otolith samples were collected. Ovarian samples were sectioned and stained with hematoxylin and eosin utilizing standard histological techniques (Fig. 8). These sections were examined to determine the maturity state of each fish sampled. The maximum ova (or embryo) diameter (MOD) was measured for each sample and a gonadosomatic index (GSI) was calculated by dividing the ovarian weight by the total weight of the fish. The MOD and GSI were utilized to examine the seasonality of the reproductive cycle.

The results from the GSI show an increase in the size of ovary through the months of March, a decrease in May as parturition is occurring, and a sharp drop-off in June after parturition has occurred (Fig. 9). The mid-range value and high variability of this value during May reflect that fish were captured both prior to and after parturition. The mean monthly MOD also follows the same trend, but since it only includes oocytes that are developing, the value for MOD peaks in May. Values for MOD in June and July were absent due to the resting stage of Pacific ocean perch oocytes during this period (Fig. 9). The reproduction of this species was found to be highly synchronous with a prolonged period of development between the beginning of vitellogenesis (yolk deposition) in July and August to parturition in May.

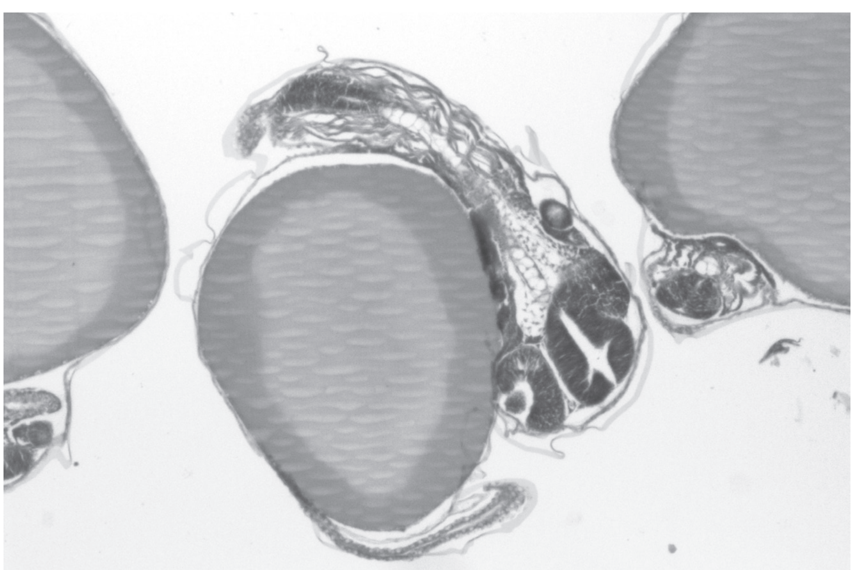


Figure 8. A histological section of a Pacific ocean perch eyed embryo.

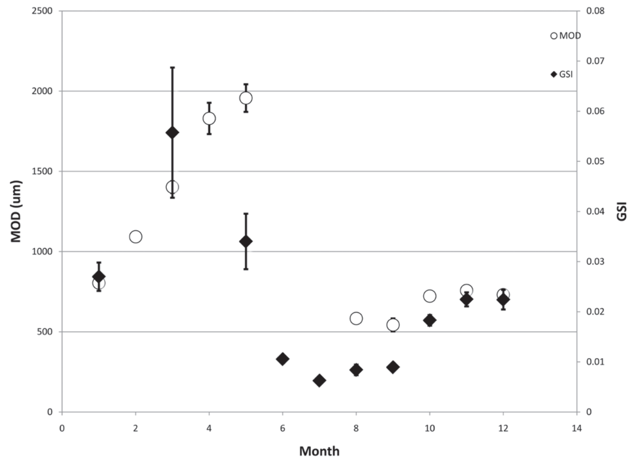


Figure 9. Mean monthly gonadosomatic index (GSI) and maximum ova diameter (MOD) values. Error bars are standard error of the mean.

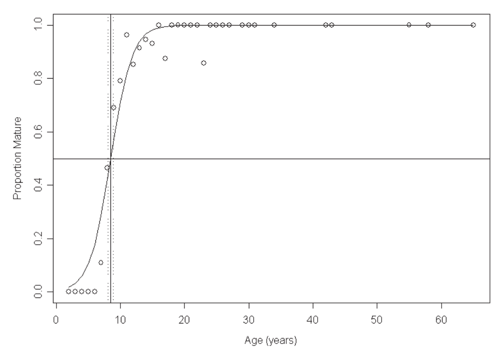


Figure 10. Logistic maturity curve for age of Pacific ocean perch.

Due to the difficulty of distinguishing maturing and resting-stage fish during the late summer months, fish collected during July and August were not included in the length at maturity calculation. The smallest mature fish was 308 mm fork length (FL) and the largest immature fish was 430 mm FL. Length at 50% maturity was calculated to be 333 mm FL. The youngest mature fish was age 7 and the oldest mature fish was age 58; the ovary of this fish was undergoing active atresia (degeneration). Only two immature fish were older than 17 years (23, 58). Age at 50% maturity was calculated to be 8.2 years (Fig. 10).

The management of Pacific ocean perch in the Gulf of Alaska is dependent upon accurate estimation of life history parameters including length and age at 50% maturity. This study found smaller and younger age and length at maturity estimates which may have important implications for stock assessment for this species in the Gulf of Alaska.

By Christina Conrath and Brian Knoth

Fish Love Worms: Habitat From the Food Perspective

Polychaetes are a large part of the diets of small-mouthed flatfish in the Bering Sea. This diverse and abundant group dominates the infauna of marine soft sediments and is widely used as an indicator of environmental change. It may also be a key factor in habitat suitability to flatfish. The AFSC's Habitat Research and Resource Ecology and Ecosystem Modeling tasks are jointly studying Bering Sea infauna for linkages with flatfish habitat and trophic dynamics. The research is funded by NOAA's Essential Fish Habitat program. Field data collection has been accomplished through cooperation with the AFSC's annual summer Bering Sea bottom-trawl survey.

Research in 2011 focused on diet comparisons between adult and young flatfish in coastal habitats. Alaska plaice, northern rock sole, and yellowfin sole were the target species. Sampling was conducted at the end of the 2011 bottom-trawl survey, along a transect of stations near the Alaska Peninsula. Benthic samples and underwater video footage of the bottom habitat were collected on the FV *Alaska Knight* (Figs. 11 and 12). The FV *Aldebaran* joined in the collection of fish specimens. Fish stomachs and tissue were extracted for prey and stable isotopes analysis, respectively, to trace short- and long-term food sources. A database of Bering Sea infauna communities and substrate properties is being incrementally assembled to examine spatial correlations with benthivorous flatfish diets and condition, and specifically, to evaluate polychaetes as the food index in habitat suitability.

By Cynthia Yeung

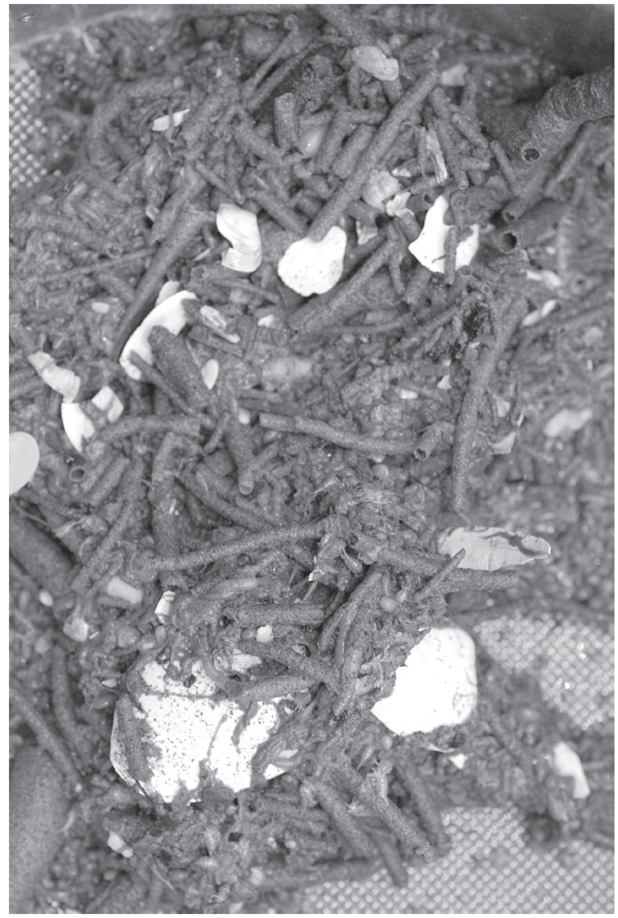


Figure 12. A polychaete sample collected during the 2011 summer Bering Sea bottom trawl survey.

Figure 11. Scientists conducting benthic sampling aboard the *Alaska Knight*.

Figure 13. Participants in the 2011 annual meeting of the Society for Invertebrate Pathology, 7 August, at Halifax, Nova Scotia.

2011 Annual Meeting of the Society for Invertebrate Pathology

Frank Morado of the Fisheries Resource Pathobiology group participated in a special symposium of the 2011 Annual Meeting of the Society for Invertebrate Pathology in Halifax, Nova Scotia, Canada, held 7-11 August 2011. The special session, sponsored by the international organization Office of Economic Cooperation and Development and titled "Disease in Aquatic Crustaceans: Problems and Solutions for Global Food Security" was held 7 August and organized and chaired by Dr. Grant Stentiford (Centre for Environment, Fisheries and Aquaculture Science, Weymouth Fish Disease Laboratory, Weymouth, Dorset, UK).

Invited members (Fig. 13) from international government agencies and academic institutions represented interests in both aquaculture and wild capture crustacean fisheries. The focus of the symposium was the impact or potential impact of disease on global food security, with respect to crustaceans. The symposium served as an information gathering meeting identifying major disease issues in wild capture crustacean fisheries and crustacean aquaculture. Dr. Morado's oral presentation was titled "Protistan parasites as mortality drivers in cold water crab fisheries." Problems in assessing the effects of disease on crustacean population abundance and distribution were discussed. Several protistan pathogens were identified that appear to cause significant mortalities in cold water crab species, but other pathogens were identified that affect product quality. In either situation, the availability of crustaceans to consumers is affected.

By Frank Morado

Midwater Assessment & Conservation Engineering Program

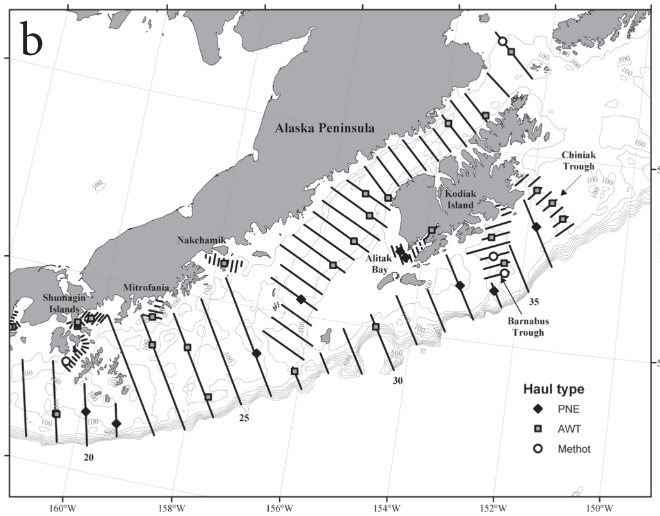
Acoustic-Trawl Survey of Walleye Pollock in the Gulf of Alaska

Midwater Assessment & Conservation Engineering (MACE) program scientists completed an acoustic-trawl survey of walleye pollock in the Gulf of Alaska (GOA) between 12 June and 12 August 2011 aboard the NOAA ship *Oscar Dyson*. The main purpose of the survey was to estimate the abundance of semi-pelagic walleye pollock and other dominant species within the GOA. Similar MACE surveys were conducted during summers 2003 and 2005.

The 2011 survey was conducted eastward from the Islands of Four Mountains to the eastern side of Kodiak Island along the GOA shelf. The survey trackline included cross-shelf transects oriented mainly north-south and spaced 20 nmi apart, as well as more closely spaced transects in the vicinity of the Shumagin Islands, Shelikof Strait, and within numerous smaller bays and inlets (Fig. 14). The survey, initially intended to cover the GOA eastward to Yakutat, was cut short by 16 days due to ship-related mechanical and personnel issues. Unlike the Bering Sea survey, where midwater trawl catches are essentially limited to walleye pollock, the GOA survey includes more bathymetrically complex areas which exhibit higher biodiversity. The combination of the shortened survey with fewer opportunities to trawl and the more diverse ecosystem led to some uncertainty in the classification of backscattering layers on the outer GOA shelf.

Acoustic backscatter data were collected along transects at five individual echosounder frequencies (18, 38, 70, 120, and 200 kHz) during daylight hours. Walleye pollock abundance estimates were based on backscatter detected at 38 kHz. Opportunistic midwater trawls were conducted to classify the backscatter attributed to walleye pollock and other organisms. A bottom trawl was used to identify near-bottom backscatter, and daytime Methot trawls were conducted to identify suspected euphausiid backscatter.

A newly developed stereo camera system (Cam-Trawl) was mounted in the back of the midwater trawl and used during most hauls. Cam-Trawl has the potential to provide information on the species and size composition of organisms throughout the entire tow path and thus provides much finer spatial scale information than possible using traditional trawl methods (Fig. 15). This information can be used to improve species classification of the acoustic data in many situations. The summer 2011 survey was the first time that the system was used in a production mode. It performed flawlessly and will be used in the future with an open codend as a high-resolution, non-extractive sampler on some hauls. Ancillary activities



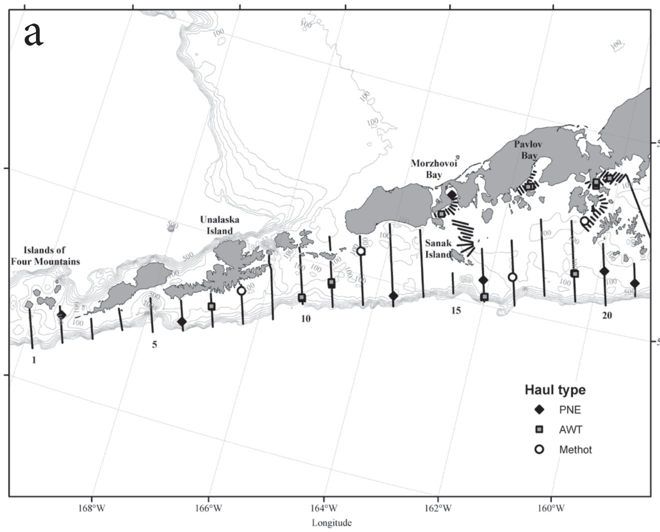


Figure 14a & b. Transect lines with locations of midwater (Aleutian wing (AWT), Methot) and bottom (Poly Nor'eastern) trawls conducted during the summer 2011 acoustic-trawl survey of walleye pollock in the Gulf of Alaska for Leg 1 (a) and Legs 2 and 3 (b). Transect numbers are included.

The summer 2011 survey was the first time that the system was used in a production mode. It performed flawlessly and will be used in the future with an open codend as a high-resolution, non-extractive sampler on some hauls.

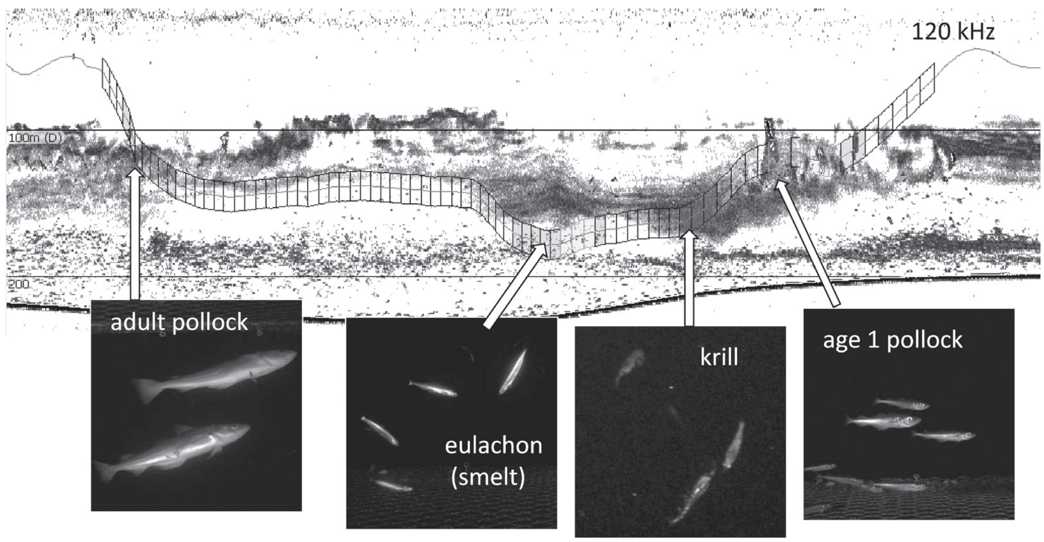


Figure 15. An example of Cam-Trawl images used to aid in classifying acoustic backscatter during the summer 2011 Gulf of Alaska acoustic survey analysis. The line representing the path taken by the trawl is overlaid on the acoustic echogram, with shades of gray indicating density of targets in CamTrawl images. These data enable classification of multiple types of acoustic backscatter within a single trawl haul.

included a multibeam bottom-mapping study, conducted predominantly at night, to determine the feasibility of classifying the seafloor as trawlable or untrawlable. A drop-camera was deployed for ground-truthing purposes. Physical oceanographic data were collected in support of the trawlability study. Underway water samples were also collected to make salinity, chlorophyll, and oxygen measurements. A multiple opening-closing codend device, which allowed several discrete samples to be taken during a single trawl haul, was used to investigate vertical distribution patterns of semi-pelagic species until it was damaged on 8 July.

Walleye pollock were found throughout the surveyed area. Approximately 45% of the pollock biomass was found on the outer GOA shelf, 35% in Shelikof Strait, 8% in Barnabas and Chiniak Troughs and the remainder in the smaller bays. Walleye pollock fork length (FL) composition differed by geographic area. Fish 35-65 cm FL with very few smaller juveniles comprised the majority on the GOA shelf, and in the Shumagin Islands, Sanak, Chiniak, Pavlov and Mitrofania Bays. Nearly all the age-1 pollock (10-18 cm) encountered during this survey were found in Shelikof Strait with a few fish in Morzhovoi Bay. The most numerous size classes were 10-18 cm (age-1) followed by the 40-55 cm FL range.

By Abigail McCarthy

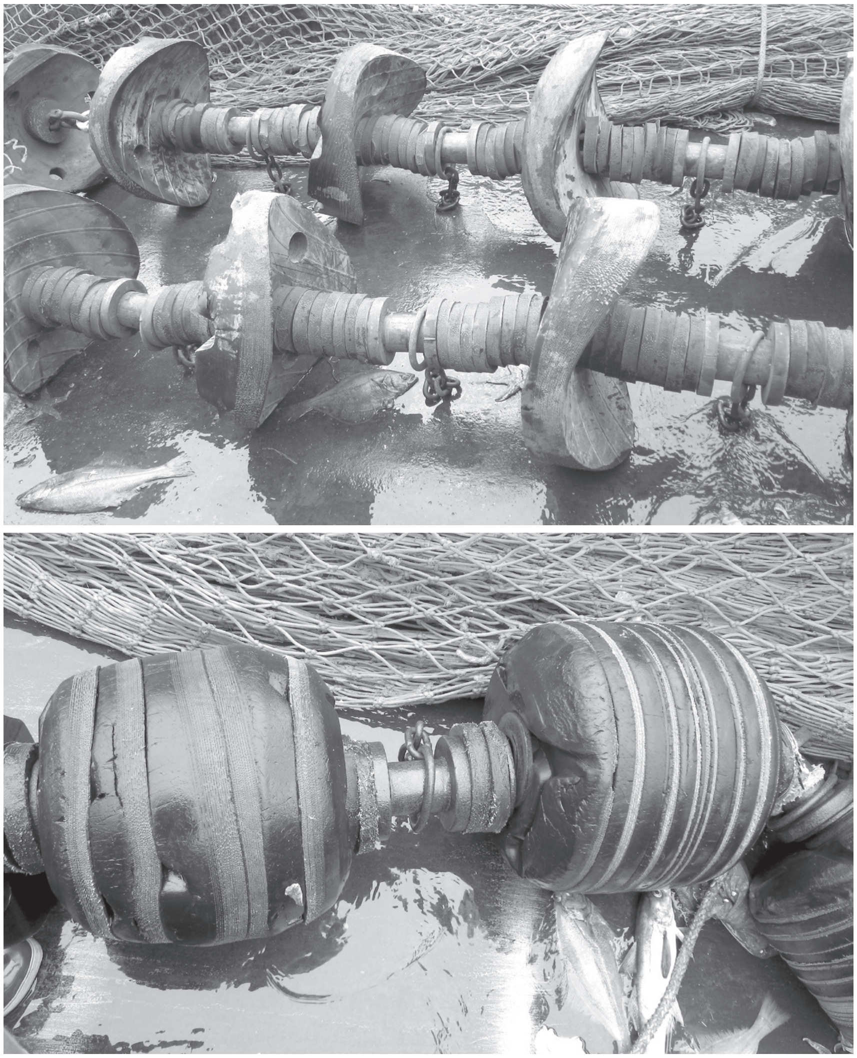


Figure 16. Two trawl footropes (disk, above - roller, below) used in studying how they affect crabs that they encounter. Photos by Carwyn Hammond.

Crabs and Trawl Footropes: How They Interact and How Effects Can Be Reduced

RACE scientists completed two field projects investigating the interactions between crabs and bottom trawl footropes. Our goal was to assess the rates of bycatch and crab mortality associated with different conventional footropes and to begin developing new footrope designs to reduce those rates.

The effectiveness of different footropes at catching their target species and crab bycatch were compared aboard the fishing vessel *Cape Horn* from 18 June to 4 July. The *Cape Horn*'s twin trawl system and processing capabilities allowed comparison of catches from simultaneous side-by-side tows of full scale trawls and commercial-scale catch rates. We compared disk and bobbin footropes (Fig. 16), as well as disk gears with substantially wider spacing. The wider spacing was a modification suggested by fishermen for reducing bycatch and damage.

The effects of these footropes on crabs that were not captured were investigated during work aboard the fishing vessel *Pacific Explorer* 10-24 August. Crabs were captured after they had passed under the footropes and examined for damage and reflex impairments. Previous work had shown that delayed mortality could be predicted from these reflex assessments. As suggested by a group of cooperating fishermen, additional tests assessed the effect of the capture process on the resulting mortality estimates, particularly the role of exposure to suspended sediments behind the footropes.

Results from both studies are being analyzed and will initially be presented to our collaborators from the fishery in November 2011.

By Craig S. Rose

Newport Laboratory: Fisheries Behavioral Ecology Program

Recruitment Signals and Post-Settlement Processes of Juvenile Gadids in Coastal Nursery Areas of Kodiak

Age-0 fish that successfully transition through early life stages may be the earliest reliable indicators of year-class strength, yet few survey data are available to test these predictions for commercially important groundfish species in Alaska. Over the past 5 years, we examined trends in annual abundance and seasonal growth and mortality in age-0 Pacific cod (*Gadus macrocephalus*) across multiple fixed-sites in two nursery embayments off Kodiak Island using beach seines (n=320 hauls) and baited cameras (n=410 deployments) (Fig. 17). The beach seine targeted age-0 fish in 2-4 m depth whereas the baited camera targeted older conspecifics (age 1 – 2) across a broader range of depths (2-20 m) adjacent to seine site locations. We used these survey data to address the following questions: 1) does post-settlement growth and mortality vary annually, and if so, 2) what processes control such variation? and 3) can bay-resident populations of age-1 and age-2 juvenile cod be predicted from the age-0 abundance or do post-settlement processes mask initial recruitment signals?

Question 1: The interannual abundance of age-0 gadids recruiting to nurseries was highly variable, but it was interesting to note that the variability was positively correlated among co-occurring gadids, age-0 saffron cod (*Eleginus gracilis*) (r2 = 71%; Fig. 18a) and age-0 walleye pollock (*Theragra chalcogramma*)(r2 = 69%; Fig. 18b). These patterns suggest a common mechanism regulates pre-settlement survival and/or successful delivery of larvae to coastal nurseries.

Question 2: Two notable trends emerged from the size and growth data. First, size-at-settlement was positively related to spring temperatures experienced by larvae, but more importantly, these differences in size were directly related to post-settlement mortality (r2 = 47%, p = 0.047; Fig. 19); i.e., larger fish in July were more likely to survive to late August in that year. Second, although age-0 density did not appear to impact mortality (Fig. 20a) there was a negative impact on post-settlement growth (r2 = 65%; Fig. 20b), suggesting nurseries may have limited resources (e.g., habitat, food) and could be a population bottleneck in years of high age-0 abundance.

Question 3: The regression analysis of age-0 abundance on subsequent year-class strength yielded mixed

Figure 17. Sampling for juvenile Pacific cod caught by a) beach seine and b) baited camera across multiple fixed-site locations in Kodiak. The survey occurred over two sampling periods (mid-July and late-August) across 5 years (2006–10).

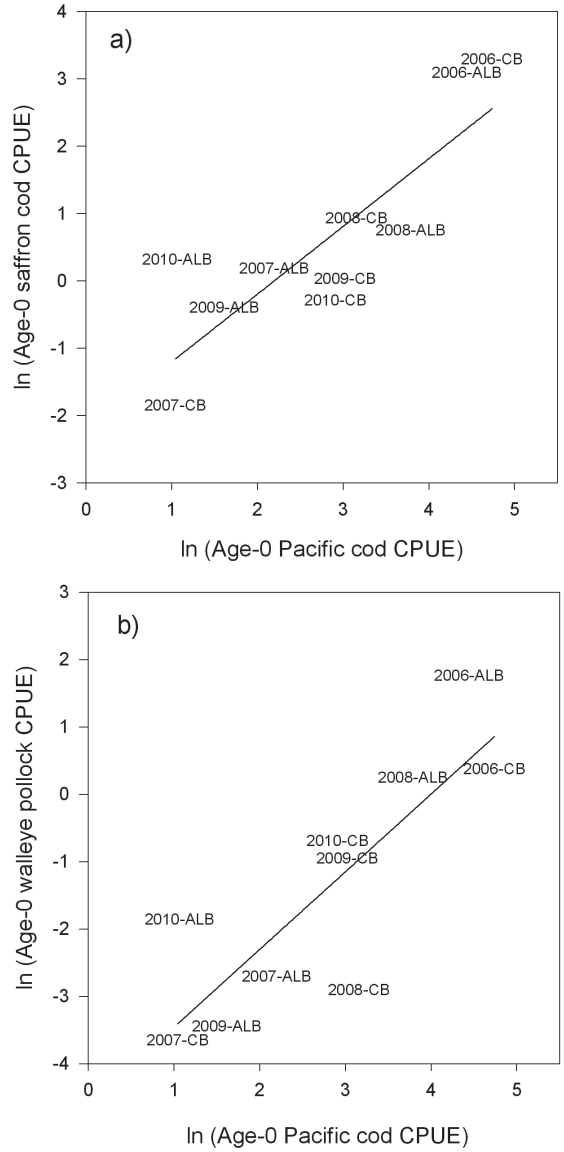


Figure 18. Interannual regional abundance of age-0 Pacific cod compared to a) age-0 saffron cod and b) age-0 walleye pollock during the same period and region. Data are based on seine catches of age-0 fish in mid-July at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-year period (2006–10).

results. For Pacific cod, age-0 abundance significantly predicted age-1 and age-2 abundance ($p<0.05$ in all instances) and there was model improvement using late estimates of age-0 abundance from August compared to July. However, all the regressions were highly leveraged by the abundant 2006 year class in ALB (hii = 0.76 – 0.93). The removal of this data point resulted in no significant relationship between age-0 and age-1 or age-0 and age-2 abundance ($p>0.05$). A more cautious interpretation is that age-0 estimates of low abundance (using beach seines) are reliable indicators of relatively low year-class strength in subsequent years whereas abundant year classes may still be prone to high rates of mortality to be considered sound indicators of recruitment strength.

Collectively, these data suggest age-0 Pacific cod abundance is a reasonable predictor of year-class strength of resident juveniles, but post-settlement sources of mortality (e.g., overwintering, predation, etc.) may be significant enough to consider the existence of additional critical periods in juvenile gadids resident to Kodiak coastal areas.

Further studies will undoubtedly need to determine how the population dynamics of juvenile cod in coastal nurseries integrate with the broader population dynamics of the Gulf of Alaska. With additional time-series data, an examination of parallels between coastal and offshore abundance data (e.g., age-0 seine data vs. age-3 trawl data) could be one means of examining such links. In the mean time, the supporting vital rate information (derived in coastal nurseries) could be used for provisional estimates of growth and natural mortality where other such data are absent or assumed in the Gulf of Alaska stock assessment.

By Benjamin J. Laurel

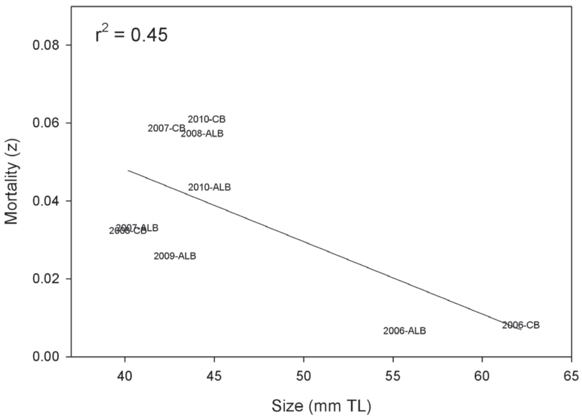


Figure 19. Influence of settlement size on mortality in age-0 Pacific cod over a 6-week period in two Kodiak nurseries areas. Size data (x-axis) are based on mean size of age-0 Pacific cod collected in mid-July in seines at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-year period (2006–10). Mortality estimates are based on relative change in abundance (catch-per-haul) from mid-July to late August, respectively.

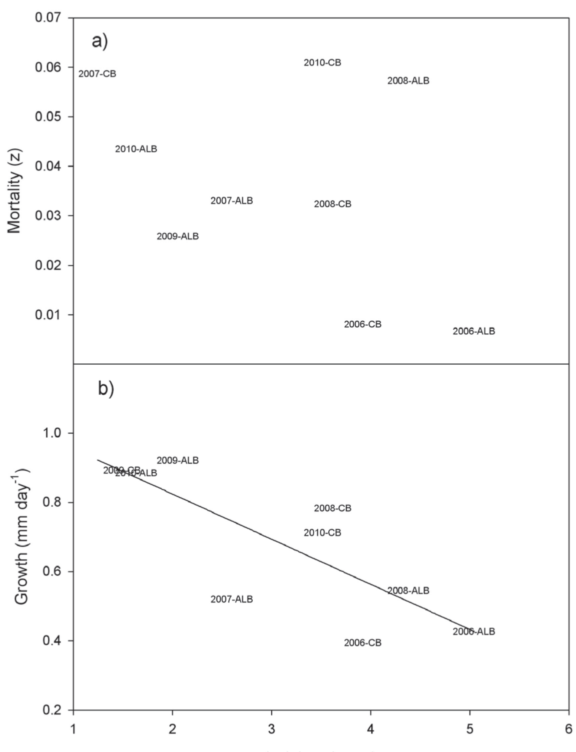


Figure 20. Influence of annual age-0 Pacific cod abundance on a) growth and b) mortality over a 6-week period in two Kodiak nurseries areas. Abundance data (x-axis) are based on seine catches of age-0 Pacific cod in mid-July at multiple sites across two regions, Anton Larson Bay (ALB) and Cook Bay (CB), over a 5-year period (2006-2010). Growth and mortality estimates are based on relative change mean length and abundance from mid-July to late August, respectively.

Recruitment Processes Program

Eco-FOCI Fall Juvenile Fish Cruise, Gulf of Alaska

Scientists from the Recruitment Processes program studied juvenile walleye pollock and flatfishes in the GOA during autumn 2011 aboard the *Oscar Dyson*. Predetermined collection sites formed grids over the continental shelf near Kodiak Island and between Shelikof Strait and the Shumagin Islands (Fig. 21). The cruise objectives were to 1) extend a time series of age-0 walleye pollock abundance at index sites within the Shelikof-Shumagin area; 2) test the utility of resource selection models (RSM) for predicting site-specific presence of flatfish over the continental shelf; and 3) collect samples of the potential prey taxa of juvenile fishes. The time series is currently being evaluated by scientists for its ability to predict pollock recruitment in the GOA. At the time-series sites, the frequency of age-0 walleye pollock occurrence in midwater was 85% (22 occurrences at 26 sites). Preliminary mean abundance at these sites, not corrected for possible diel effects on catch, was higher in 2011 than in 2001, 2003, 2007, and 2009, but lower than in 2000 and 2005. The average standard length of all measured age-0 walleye pollock was 82 mm (n=1,322, size range = 52 – 127 mm). Data on juvenile flatfish presence, sediment composition, and environmental conditions were collected at 35 sites to examine the utility of RSM for predicting the presence of juvenile flatfishes on the continental shelf of the western GOA. Potential prey of midwater and benthic juveniles was sampled at nine sites to examine the possibility that specific geographic areas may offer favorable feeding conditions for a diverse assemblage of juvenile fishes. At nine other sites, the seafloor was too rough to sample on bottom so only a midwater sample was collected. This additional sampling was to supplement collections made for the North Pacific Research Board-sponsored GOA-Integrated Ecosystem Research Program and for a study of otolith element composition. Two oceanographic moorings were recovered and one was deployed in the vicinity of Chiniak Gully. Analysis of the data and samples is currently underway.

By Matt Wilson

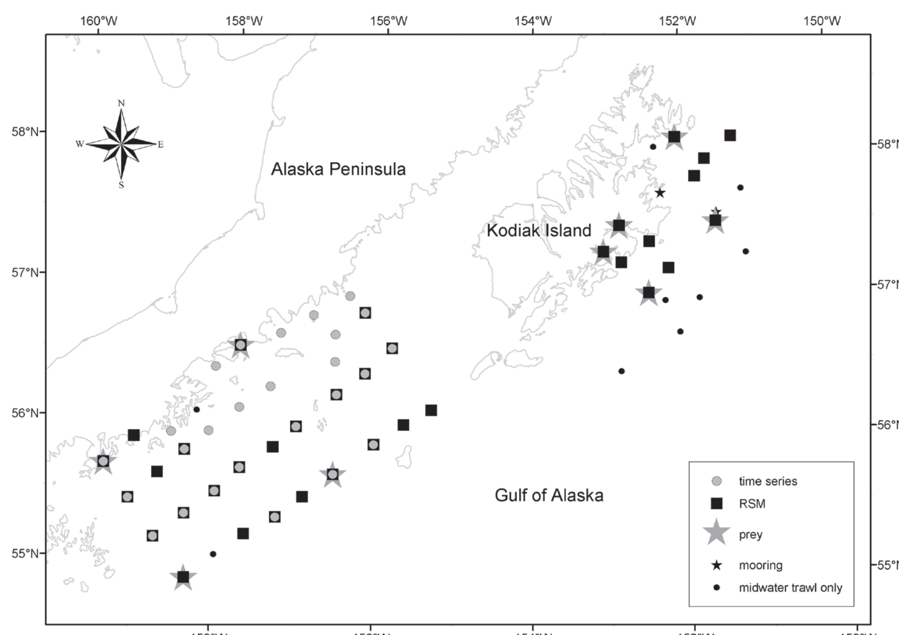


Figure 21. Collection site locations occupied during 1-14 October 2011. Symbols identify which cruise objectives or activities were addressed at each site.

Chukchi Acoustic, Oceanographic, and Zooplankton (CHAOZ) Study

The RACE Recruitment Processes Program, NMML Cetacean Assessment & Ecology Program, and Pacific Marine Environmental Laboratory (PMEL) Ocean Environment Research Division are partnering on a multi-disciplinary examination of the eastern Chukchi Sea ecosystem called CHAOZ (CHukchi Acoustic, Oceanographic, and Zooplankton). The program relies on both NOAA and external funding (U.S. Bureau of Ocean Energy Management, Regulation, and Enforcement). Scientists are using summer shipboard observations and year-round measurements from moored instruments to 1) assess the seasonal occurrence and relative abundance of whales in the region, 2) understand how environmental variability influences whale distribution and relative abundance, and 3) predict how future climate-mediated changes in environmental conditions (e.g. sea ice extent) will modify habitat use by large whales.

Scientists completed their second cruise to the region this past September working on the fishing vessel *Mystery Bay*, a 170-ft Bering Sea crabber. The boat accommodated 12 scientists at any one time; in addition to AFSC and PMEL employees, scientists from the U.S. Fish & Wildlife Service, the International Fund for Animal Welfare, and Cornell University participated. During the cruise, all moorings and instruments deployed in 2010 were successfully recovered. Underway acoustic and visual surveys for the distribution and abundance of marine mammals were collected during transits as well as visual surveys of seabirds. Hydrographic stations (Fig. 22) focused on obtaining information on the physical and chemical properties of the water column (temperature, salinity, dissolved nutrients, dissolved oxygen, light, chlorophyll) and the availability of prey for baleen whales. A new set of instruments was deployed that will overwinter and be retrieved late summer 2012. While the new instruments collect data, scientists will be hard at work trying to analyze and interpret data from the 2010 deployments. Stay tuned to learn what new ecosystem insights have been gained from winter and early spring measurements.

By Jeffrey Napp

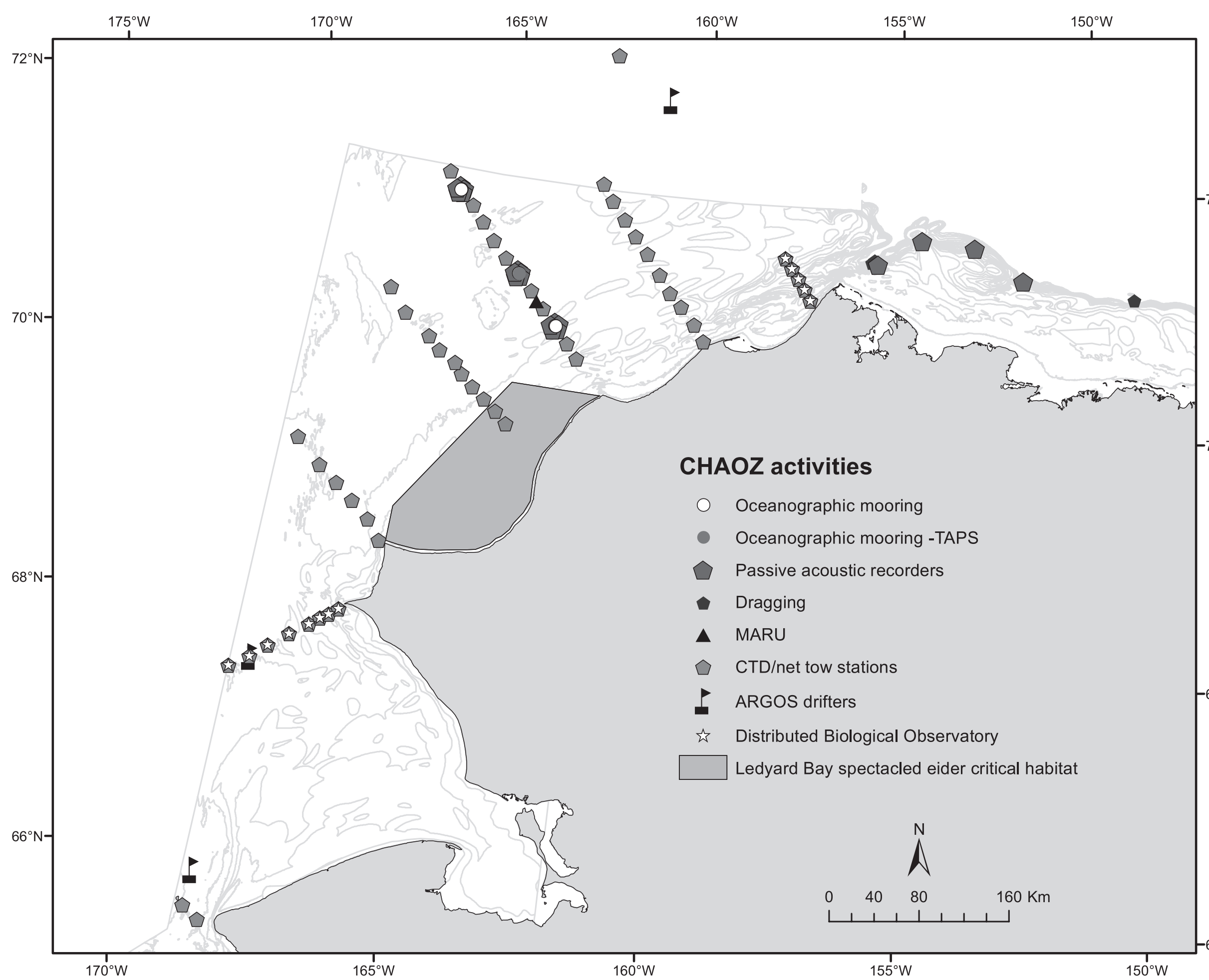


Figure 22. 2011 CHAOZ Cruise Trackline and Station Locations. This figure shows the locations and variety of scientific measurements made during this interdisciplinary cruise which focused on habitat suitability for large whales in the Chukchi Sea. Figure courtesy of Jessica Crance, NMML.

Resource Ecology & Ecosystem Modeling Program

Arrowtooth Flounder Diets in the Eastern Bering Sea and Gulf of Alaska, 2007–10

The arrowtooth flounder (*Atheresthes stomias*) is an ecologically important predator in the eastern Bering Sea and the Gulf of Alaska, and stomach samples are regularly collected from this species during resource surveys in Alaskan waters. Here we present the gravimetric diet composition (% weight) for different size-categories of arrowtooth flounder from 2007–10 summer surveys in the eastern Bering Sea, and from 2007 and 2009 surveys in the Gulf of Alaska (Fig. 1). The tendency for arrowtooth flounder to become more piscivorous with increasing size is consistent among years in both regions. Euphausiids and shrimp generally decrease as a percentage of the weight of the stomach contents, with increasing size of arrowtooth flounder. In the eastern Bering Sea, walleye pollock is the dominant fish prey, and the identifiable fishes in the miscellaneous fish category typically shift from stichaeids to zoarcids to pleuronectoids with increasing size of arrowtooth flounder. In the Gulf of Alaska, osmerid and clupeid prey is consistently important, and the identifiable fishes in the miscellaneous fish category are more variable, but stichaeids and pleuronectoids are prevalent. Instances of cannibalism, although fairly rare in arrowtooth flounder, were more frequent in the Gulf of Alaska than in the eastern Bering Sea. Unexpectedly, the low percentage of euphausiid prey in 2009 in the eastern Bering Sea coincides with the peak of euphausiid abundance found by AFSC hydroacoustic surveys from 2004 through 2010.

The tendency for arrowtooth flounder to become more piscivorous with increasing size is consistent among years in both regions.

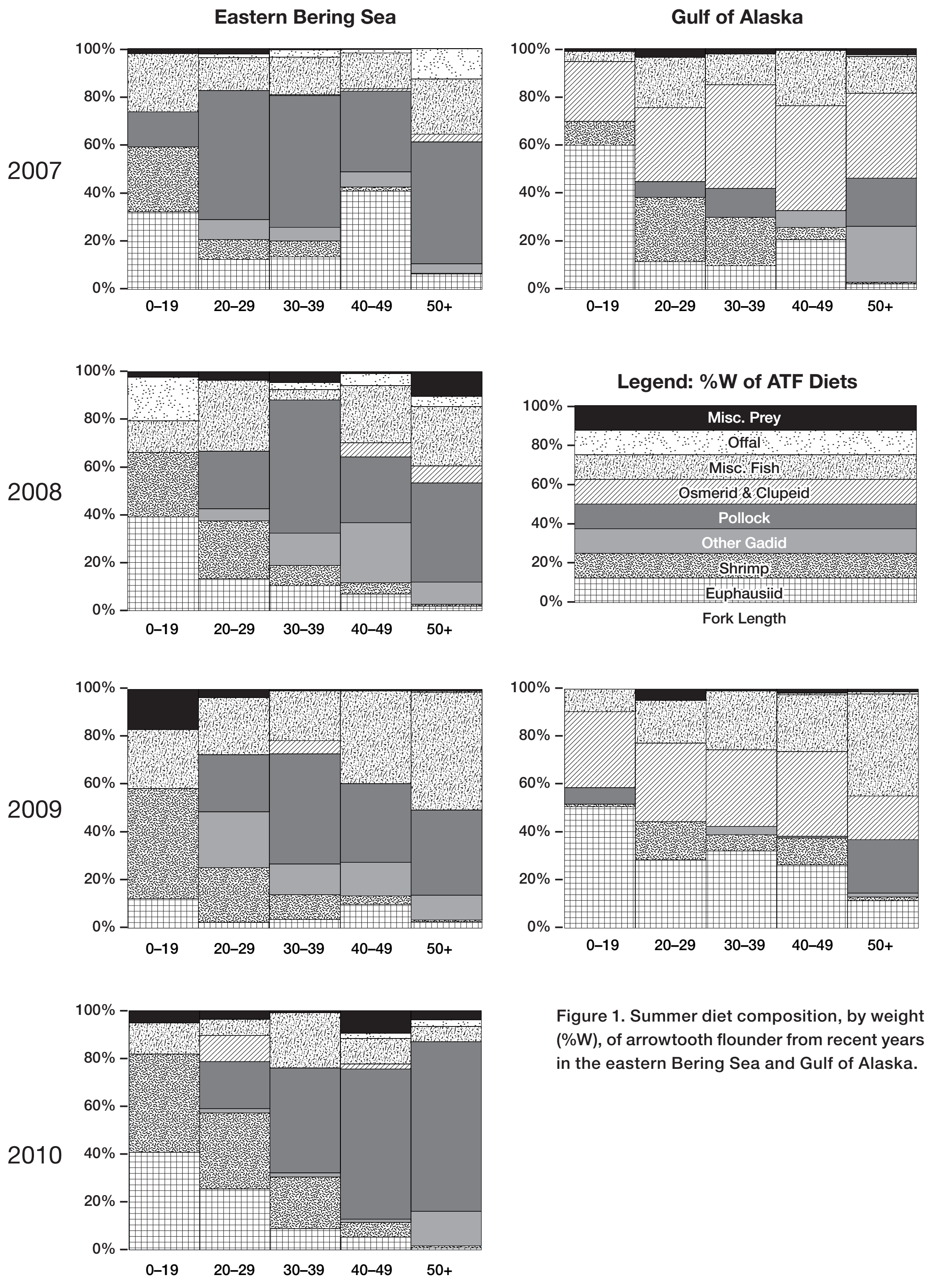


Figure 1. Summer diet composition, by weight (%W), of arrowtooth flounder from recent years in the eastern Bering Sea and Gulf of Alaska.

By Troy Buckley and Sean Rohan

A total of 12,964 stomach samples were collected from a variety of sources during the third quarter.

Fish Stomach Collection and Lab Analysis

During the third quarter of 2011, Resource Ecology and Ecosystem Modeling (REEM) program staff focused their analyses of stomach contents on samples from the Gulf of Alaska and the Aleutian Islands. The contents of 1,991 stomach samples from 18 species were analyzed from the Gulf of Alaska, and 2,585 stomach samples from 32 species were analyzed from the Aleutian Islands. REEM staff also analyzed 250 stomach samples from six species from the eastern Bering Sea. In total, 24,244 records were added to the REEM food habits database. Tissue samples of muscle and liver from arrowtooth flounder, Pacific cod, and walleye pollock have been dried, ground, and tinned (400, 284 and 423, respectively) in preparation for stable isotope analysis.

A total of 12,964 stomach samples were collected from a variety of sources during the third quarter. Fishery observers collected stomach samples from 547 walleye pollock, 43 Pacific cod, and 2 Atka mackerel from Alaskan fishing grounds. The AFSC's bottom trawl survey of the eastern Bering Sea returned 5,150 stomach samples from four species. The hydroacoustic survey of the Gulf of Alaska provided 1,146 stomach samples from 11 species. The AFSC's bottom trawl survey of the Gulf of Alaska collected 3,591 collected samples from 34 species. Shipboard analysis of stomach contents was also conducted on board one of the Gulf of Alaska bottom trawl survey vessels, providing data from 2,485 additional stomachs.

By Troy Buckley, Geoff Lang, Mei-Sun Yang, Richard Hibpshman, Kimberly Sawyer, Caroline Robinson, Sean Rohan, Kelsey Kappler and Cy'Anna Scott

Aleutian Islands Ecosystem Assessment Workshop

The Aleutian Islands Ecosystem Assessment Team met in September 2011 to begin developing a structuring theme and key indicators for the Aleutian Islands ecosystem to be included in a new ecosystem assessment. The team includes AFSC scientists Stephani Zador, Kerim Aydin, Steve Barbeaux, Libby Logerwell, Ivonne Ortiz, Sandra Lowe, Lowell Fritz, Paul Wade, and Chris Rooper; Nick Bond from the University of Washington's Joint Institute for the Study of Atmosphere and Ocean; Jim Estes from University of California, Santa Cruz; Diana Evans from the North Pacific Fishery Management Council (NPFMC); Dave Fraser from Port Townsend, Washington; Stephen Jewett from University of Alaska Fairbanks; Carol Ladd from NOAA's Pacific Marine Environmental Laboratory; John Olson NMFS Alaska Regional Office; John Piatt from U.S. Geological Survey; Jon Warrenchuk from Oceana; Francis Weise from the North Pacific Research Board; and Jeff Williams from U.S. Fish and Wildlife Service.

Following presentations and review of existing physical and biological data, the team concluded that the significant variability in the island chain ecosystem warranted structuring the Aleutian Islands ecosystem assessment by three ecoregions: western, central, and eastern. The ecoregions were chosen based upon evidence of significant ecosystem distinction from the neighboring ecoregions. The team also concluded that developing an assessment of the ecosystem at this regional level would emphasize the variability inherent in this large area, which stretches 1,900 km from the Alaska Peninsula in the east to the Commander Islands in the west.

The three Aleutian Islands ecoregions used in this assessment are defined from west to east as follows. The Western Aleutian Islands ecoregion spans 170° to 177°E. These are the same boundaries as the North Pacific Fishery Council fishery management unit 543. The Central Aleutian Islands ecoregion spans 177°E to 170°W. This area encompasses the North Pacific Fishery Council fishery management units 542 and 541. There was consensus among the group that the eastern boundary of this ecoregion occurs at Samalga Pass, which is at 169.5°W, but for easier translation to fishery management area, it was agreed that 170°W was a close approximation. The Eastern Aleutian Islands ecoregion spans 170°W to False Pass at 164°W.

The team was tasked with choosing a suite of indicators that together provide a comprehensive view of the Aleutian Island ecosystem reflecting across trophic levels from the physical environment to top predators and humans, as well as both the nearshore and offshore. In addition to providing the "vital signs" for the Aleutian Islands, the preliminarily chosen indicators needed to be updatable on a regular basis, preferably annually; however, the team recognized that many of the surveys that collect data for some indicators do not occur every year. Numerous gaps in available time series were noted and discussed. Although a single suite of indicators was chosen for the entire ecosystem, not all indicators are available or applicable in each of the three ecoregions.

The following indicators were selected for the Aleutian Island ecosystem assessment: 1) the Winter North Pacific Index; 2) reproductive anomalies of least auklet and crested auklets; 3) proportions of hexagrammids, gadids, and *Ammodytes* in tufted puffin chick diets; 4) apex predator and pelagic forager fish biomass indices; 5) sea otter counts; 6) Steller sea lion non pup counts; 7) the percent of shelf <500 m trawled; and 8) school enrollment.

The Ecosystem Assessment will be presented to the NPFMC's joint plan teams for the groundfish fisheries of the Gulf of Alaska and Bering Sea Aleutian Islands in November 2011 and to the NPFMC in December 2011 as part of the annual catch specification process. The final report will be available at http://access.afsc.noaa.gov/reem/ecoweb.

By Stephani Zador

American Fisheries Society Annual Meeting

Several REEM program personnel attended the Annual American Fisheries Society meeting in Seattle, Washinton, on 4-18 September 2011. Talks presented by REEM personnel included:

- "Incorporating Predation and Temperature into Multi-Species Statistical Catch-At-Age Models: An Example from the Bering Sea"(Holsman, Aydin, and Ianelli)
- "Incorporating Ecological Covariates in Fisheries Models: Comparing Surplus Production Estimates Fit With and Without Environmental and Ecological Covariates for 13 Large Marine Ecosystems in the Northern Hemisphere" (Holsman)
- "A Recent Indicator-Based Assessment for the Eastern Bering Sea" (Zador)
- "Assembly Rules for Aggregate-Species Production Models: Simulations in Support of Management Strategy Evaluation" (Gaichas)
- "Ecosystem Modeling in Support of Alaskan Fishery Management from the Aleutians to the Arctic" (Aydin)

By Kirstin Holsman and Kerim Aydin

Economics & Social Sciences Research Program

Center for Independent Experts Review: Bering Sea and Aleutian Islands Crab Economic Data Report Program

The Economic and Social Sciences Research (ESSR) program partnered with the Center for Independent Experts (CIE) to undertake a peer review of methodological practices employed in the development and administration of the Bering Sea and Aleutian Islands (BSAI) Crab Economic Data Report (EDR) program. The crab EDR program has been managed by the ESSR program under the direction of the North Pacific Fishery Management Council (Council) and in accordance with 50 CFR 680.6 since the transition to the rationalized management regime in 2005. The EDR program is currently under consideration by the Council for substantial revisions to address changing analytical objectives, data quality limitations, and excessive submitter burden. Final action by the Council to identify mandatory economic reporting requirements is expected in December 2011, with regulatory changes and implementation procedures to be developed subsequently. To support implementation of the Council's final action concerning the BSAI crab EDR program using best scientific and methodological practices, the AFSC has sought guidance from independent experts in the fields of applied economic analysis of fishery resource management, design and testing of economic surveys of business establishments, and methods for data quality assessment and data quality control.

The CIE steering committee appointed the following individuals to provide independent peer reviews:

- Dr. Susan Hanna, Professor Emeritus of Marine Economics, Oregon State University
- Dr. Danna L. Moore, Associate Director, Social & Economic Sciences Research Center, Washington State University
- Dr. Richard Wang, Director, Information Quality Program, Massachusetts Institute of Technology

The panel convened a public meeting at the AFSC on 23-24 August 2011. The meeting was chaired by Dr. Chris Anderson of University of Rhode Island and included the participation of crab industry representatives and other members of the public. ESSR program staff and contractors presented documentation of methods and practices employed to date in the implementation of the data collection, validation, and dissemination, and panel members engaged both agency staff and industry participants in active discussion throughout the course of the meeting. The completed peer review reports were received on 3 October, and the meeting chair's report is being finalized. All completed reports and documents used in the review are available on the ESSRP webpage at http://www.afsc.noaa.gov/REFM/Socioeconomics/default.php. General findings of the panel noted the advances made in implementation and validation of economic data collection in commercial fisheries by the EDR program in collaboration with industry participants, despite significant limitations associated with survey design, recordkeeping practices, and constraints on more timely modification of survey instruments in response to data quality limitations and changing conditions in the fishery. Panel recommendations include methodological improvements in survey design and development and application of data quality standards. Recommended process improvements included improved collaboration between industry and agency personnel, and appointment of a standing technical body similar to the Council's plan development teams to be tasked with coordinating and advising in the development and implementation of best practices for economic data collection and analyses.

By Brian Garber-Yonts,
Ron Felthoven, and Jean Lee

Improving Community Profiles for the North Pacific Fisheries

As in other public policy arenas, incorporating community voices into the fisheries management process in Alaska is difficult. Alaska contains difficult terrain that makes travel around the state difficult and expensive. Subsistence fishing and hunting and involvement in commercial fishing activities often take precedence over attending fisheries management meetings. Although state and federal fisheries managers are required to obtain public input on fishing regulations, Alaskan communities have conveyed a sense of disenfranchisement from the decision-making process that ultimately affects their participation in commercial, sport, or subsistence fishing. In order to provide baseline information about a large number of Alaskan fishing communities to fisheries managers, the ESSR program compiled existing information about, and published community profiles for 136 Alaskan fishing communities with baseline information from the year 2000.

Now that these data are over 10 years old, the ESSR program is in the process of updating the community profiles. As a first step, the communities to be included in the updated document were reevaluated to ensure that communities with significant reliance on commercial, recreational, and subsistence fishing are included. This resulted in a total of 195 communities that will be profiled, including the original 136 communities profiled in the 2005 *Community Profiles for North Pacific Fisheries – Alaska* (Community Profiles; Sepez et al. 2005) and an additional 59 communities that were not previously included. Second, through input from community representatives from around the state, we have developed a new template for the profiles and will be adding a significant amount of new information to help provide a better understanding of each community's reliance on fishing. The community profiles will comprise additional information including, but not limited to, annual population fluctuation, fisheries-related infrastructure, community finances, natural resources, educational opportunities, fisheries revenue, shore-based processing plant narratives, landings and permits by species, and subsistence and recreational fishing participation. In addition, the profiles will provide information about the Western Alaska Community Development Program and regional profiles. A team of researchers will be assembled in late 2011 to start the process of revising the profiles. A draft of each community's profile will be sent to representatives of that community for input before they are finalized. Once finalized, the profiles will be posted on the AFSC website.

By Amber Himes-Cornell

Multi-regional Computable General Equilibrium Model Developed for North Pacific and West Coast Fisheries

Many of the vessels operating in North Pacific fisheries are owned and crewed by residents of West Coast states, especially Washington and Oregon. Some of these vessels also tend to participate in West Coast fisheries during the year. Expenditures made by these vessels generate income in port and may also have multiplier and spillover effects in other regions. Assuming that all expenditures are made locally will significantly overestimate economic impacts in a given region. Taking account of the regional distribution of expenditures made by North Pacific fishing vessels in Alaska, West Coast states and elsewhere in the United States will enhance our ability to model the overall economic impacts of North Pacific and West Coast fisheries. We constructed a three-region (Alaska, West Coast, and rest of the United States) social accounting matrix (SAM) using 1) data that was previously used to develop a single-region Alaska computable general equilibrium (CGE) model, 2) data developed by the Northwest Fisheries Science Center for the IO-PAC model of West Coast fishery sectors, and 3) data on interregional trade from IMPLAN. Using the SAM, we developed a multiregional CGE (MRCGE) for the three regions. Currently, we are conducting various simulation experiments that calculate the impacts from changes in the total allowable catch, the world demand for North Pacific seafood, and the exchange rate. The model will be used to calculate the regional and interregional economic impacts of North Pacific and West Coast fisheries. In the future, the MRCGE model will be fully integrated with Mike Dalton's global GTAP model, resulting in a full multi-regional, multi-country CGE model (if funding is available).

By Chang Seung and Mike Dalton

The Effect of Decreasing Seasonal Sea Ice Cover on the Bering Sea Pollock Fishery

The winter fishing season of the Bering Sea pollock fishery occurs during the period of maximum seasonal sea ice extent, but harvesters avoid fishing in ice-covered waters. Global climate models predict a 40% reduction in winter ice cover by 2050. This may have implications for the costs that vessels incur when traveling to and around their fishing grounds, or may open entirely new areas to fishing. Using retrospective data from 1999 to 2009, a time period of extensive annual climate variation, we analyzed variation in the distribution of the fishery. We compared the distribution of fishing in warm and cold years to estimate the degree to which fishing is displaced by ice cover. We used projections of average ice cover and bottom temperatures from Intergovernmental Panel on Climate Change (IPCC) model scenarios to characterize how the frequency of cold and warm years in the Bering Sea is projected to change through 2050. We simulated the predicted changes in ice conditions and compared the projected distribution of fishing to the observed distribution of fishing. The predicted redistribution of effort is small, largely because the winter fishery is driven by the pursuit of roe-bearing fish whose spawning location is stable. Some areas show a significant change in the quantity of fishing effort, however.

By Lisa Pfeiffer and Alan C. Haynie

Comprehensive Data Collection on Fishing Dependence of Alaska Communities

Much of the existing economic data about Alaskan fisheries is collected and organized around different units of analysis, such as counties (boroughs), fishing firms, vessels, sectors, and gear groups. It is often difficult to aggregate or disaggregate these data for analysis at the individual community or regional level. In addition, at present, some relevant community-level economic data simply are not collected at all. As a result, the NPFMC, the AFSC, and community stakeholder organizations have identified ongoing collection of community-level socio-economic information as a priority. The purpose of this project is to build on existing data and respond to this priority by gathering information about individual community involvement in fishing that is currently lacking and limits the ability of regulators to effectively analyze the potential impacts of fisheries management decisions at the community level. These data will aid scientists and NPFMC staff in better understanding Alaskan communities' social and economic ties to the fishing industry. These data also will facilitate the analysis of potential impacts of catch share programs and coastal and marine spatial planning efforts as they are more fully implemented as U.S. federal fisheries management tools.

To implement this project, the Alaska Community Survey was developed and implemented during summer 2011. Surveys were sent to community leaders in 181 fishing communities. As of the end of September 2011, surveys for 111 communities have been returned, representing a response rate of 61.3%. The information collected in the survey included time series data, information on community revenues based in the fisheries economy, population fluctuations, fisheries infrastructure available in the community, support sector business operations in the community, community participation in fisheries management, and effects of fisheries management decisions on the community. Over the coming months, attempts will be made to retrieve completed surveys from the remaining 70 communities. The data received from the surveys will be used to update the *Community Profiles for North Pacific Fisheries – Alaska* (NOAA Tech Memo NMFS-AFSC-160) and to provide summary statistics on fishing communities throughout different regions of Alaska.

By Amber Himes-Cornell

Why Economics Matters for Predicting the Effects of Climate Change on Fisheries

Research which attempts to predict the effect of climate change on fisheries often neglects to consider how harvesters respond to changing economic, institutional, and environmental conditions, which leads to the overly simplistic prediction of "fisheries follow fish." However, the climate effects on fisheries can be complex because they occur through physical, biological, and economic mechanisms that interact or may not be well understood. While most find it obvious to include physical and biological factors in predicting effects of climate change on fisheries, the behavior of fish harvesters also matters for these predictions. We present a general but succinct conceptual framework for investigating the effects of climate change on fisheries that incorporates the biological and economic factors that determine how fisheries operate. While the uncertainty surrounding long-term projections is inherent in the complexity of the system, the use of this framework will result in more complete, reliable, and relevant investigations of the effect of climate change on fisheries.

By Alan C. Haynie and Lisa Pfeiffer

A Stated Preference Analysis of Marine Recreational Fishing in Alaska

Knowledge of how anglers value their fishing opportunities is a fundamental building block of sound marine policy, especially for stocks where there is conflict over allocation between different sectors. In this work, we estimate how much 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. For more details about the survey, see Lew, Lee, and Larson (2010). Each survey included several stated preference questions that asked respondents to select the option they liked best and least from two saltwater boat fishing trip alternatives and a third non-saltwater fishing alternative. Responses to these questions provide information about anglers' preferences and values for saltwater fishing and the trade-offs they are willing to make between catch, size, and harvest regulations of different species.

Separate fishing trip values were estimated for Alaska resident anglers and non-resident anglers. For single-day trips where one species is caught with catches equaling the allowable bag (or take) limit, Alaska resident anglers had total values ranging from $246 to $444 (U.S. dollars). Non-residents had much higher total values for the same fishing experiences (ranging from $2,007 to $2,639), likely due to the fact that the trips are both less common and considerably more expensive to participate in given the travel costs to Alaska. Non-residents generally had significant positive values for increases in number caught, bag limit, and fish size, while Alaska residents valued size and bag limit changes but not catch increases. The estimated mean net opportunity cost of a day spent fishing ranges from $0-27 for Alaska residents and $309 for non-residents.

By Dan Lew

The Role of Economics in the Bering Sea Pollock Fishery's Adaptation to Climate Change

Seasonal sea ice in the Bering Sea is predicted to decrease by 40% by 2050, resulting in more frequent warm years characterized by reduced winter ice cover and a smaller cold pool (<1.5°C bottom temperature). Retrospective data from the pollock catcher/processer fishery were used to study the behavior of harvesters in past climate regimes to make inferences about future behavior in a warmer climate. We found that in the pollock fishery, large differences in the value of catch resulting from the pursuit of roe-bearing fish in the winter fishing season result in disparate behavior between the winter and summer fishing season. In the winter season, warm years and high abundances drive more intensive effort early in the season to harvest earlier-maturing roe. In the summer season, a smaller cold pool and high abundances are correlated with decreased effort in the northern reaches of the fishing grounds. Spatial price differences are associated with changes in the distribution of effort of approximately the same magnitude. Although biological evidence suggests that the predicted increased frequency of warmer regimes may result in decreasing abundances, the historical data is insufficient to predict behavior in warm, low abundance regimes. This study provides insight into the economic drivers of the fishery, many of which are related to climate, and illustrates the difficulty in making predictions about the effects of climate change on fisheries with limited historical data.

By Alan C. Haynie and Lisa Pfeiffer

Developing an Economic Survey of Alaska Saltwater Sport Fishing Charter Boat Operators

To assess the effect of current and potential regulatory restrictions on Alaska charter boat fishing operator behavior and welfare, it is necessary to obtain a better general understanding of the industry. Some information useful for this purpose is already collected from existing sources, such as from the Alaska Department of Fish and Game (ADF&G) logbook program. However, information on vessel and crew characteristics, services offered to clients, and costs and earnings information are generally not available from existing data sources and thus must be collected directly from the industry through voluntary surveys. Initial scoping and design of the survey was based on consultation with the NMFS Alaska Regional Office, ADF&G, NPFMC, and International Pacific Halibut Commission staff members regarding analytical needs and associated data gaps and experience with collecting data from the target population. In order to address the identified data gaps, AFSC researchers have begun development of a survey of Alaska charter business owners.

The survey is expected to collect annual costs and earnings information about charter businesses and the general business characteristics of Alaska charter boat operations. Types of data that will be gathered through the survey include information about costs and sources for services, equipment and supplies purchased by charter businesses, services offered to clients and associated sales revenues, crew employment and pay, vessel characteristics, and historical fishery participation. In order to refine the survey questions, AFSC researchers conducted focus groups with charter business owners in Homer and Seward in September 2011. The survey is expected to be implemented in 2012, pending available funding, completion of the survey development and testing process, and clearance for the data collection by the U.S. Office of Management and Budget under the Paperwork Reduction Act. Additionally, researchers from other NOAA Fisheries Science Centers have conducted, or are currently conducting, similar surveys of for-hire charter boat operations in other regions of the United States.

By Amber Himes-Cornell, Brian Garber-Yonts, and Dan Lew

Status of Stocks & Multispecies Assessment Program

Exploring Climate Impacts of Growth on Eastern Bering Sea Yellowfin Sole

AFSC researchers Tom Wilderbuer, Jim Ianelli, Beth Matta, and Tom Helser conducted a study on the use of climate-growth relationships of Bering Sea yellowfin sole to improve stock assessments. Recent applications of dendrochronology (tree-ring techniques) have been used to develop biochronologies from the otolith growth increments of northern rock sole (*Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), and Alaska plaice (*Pleuronectes quadrituberculatus*) in the eastern Bering Sea. These techniques ensure that all growth increments are assigned the correct calendar year, allowing for estimation of somatic growth by age and year for chronologies that span approximately 50 years and indicate that somatic growth is highly correlated with water temperature. Yellowfin sole length/weight data collected when obtaining otolith samples in AFSC surveys (n=7,000) also indicated that length and weight at age was variable and seemed to relate to summer bottom water temperature observations with a lag of 2-3 years for the temperature effect to be seen. The analysis indicates that yellowfin sole somatic growth is positively correlated with May bottom water temperature in the Bering Sea. The results for yellowfin sole were used to explore climate impacts on growth by incorporating the temperature-dependent growth into an age-structured stock assessment model and then comparing the results with the base model that uses time-invariant growth.

Preliminary results indicate that warm and cold ocean conditions influence the time series of spawning biomass estimates and may have an impact on female spawning biomass per recruit estimates. Inclusion of variable growth in the assessment model may also increase the uncertainty on spawning biomass which may also increase the buffer between the acceptable biological catch and overfishing level estimates for yellowfin sole. The authors plan to use Intergovernmental Panel on Climate Change (IPCC) climate scenarios to forecast their impact on yellowfin sole stock conditions.

By Tom Wilderbuer

What Influences Fisheries Production? Comparing the Effects of Environmental, Fishing, and Food Web Forcing Across Large Marine Ecosystems

With growing interest in taking an ecosystem approach to fisheries management, it is increasingly important to understand the complex forces regulating ecosystem dynamics. In particular, how do climate forcing and food web structure interact to support fisheries production, and what processes amplify, dampen, or obstruct the production that ecosystems provide? AFSC researcher William Stockhausen and several colleagues organized a symposium at the American Fisheries Society 141st Annual Meeting on this topic. In the symposium, results of an international workshop were presented that focused on applying multiple surplus production models to widely diverse ecosystems of the world's oceans to understand how multiple drivers of productivity in fishery ecosystems simultaneously interact to determine overall production levels. These drivers reflect a triad of factors influencing fisheries production including fisheries, the environment, and trophodynamics (food web interactions).

The presentations in the session described a common methodological framework (i.e., surplus production models) that was applied across multiple levels of aggregation (e.g., single species, taxonomic, trophodynamic, functional and whole ecosystem) for 14 large marine ecosystems in the northern hemisphere and examined model outputs from multiple production modeling packages. They also estimated management-relevant metrics and ecosystem attributes and compared them across populations and ecosystems and described the utility of applying surplus production models in single-species, multi-species, and aggregate species group frameworks. The results particularly elucidate those links between the biogeochemistry, ecology, and harvesting in these ecosystems that are globally consistent. They also highlight some challenges of fitting such production modeling approaches to similar species or functional guilds in contrasting arrangements (different species within ecosystems and similar species between ecosystems) to better delineate what controls ecosystem fisheries productivity. Implications of these results for future work relevant to operational oceanography, population and community modeling, and ecosystem-based fisheries management were also discussed.

…results of an international workshop were presented that focused on applying multiple surplus production models to widely diverse ecosystems of the world's oceans…

William Stockhausen coauthored and presented at the meeting the paper "Taking the Final Step: Can a Full Multispecies Production Model Tell Us Anything Single-Species Models with Covariates Can't?" The abstract follows.

We define extended single-species production models (ESSPMs) as single species production models that incorporate time series of principal prey and/or predator species as biological covariates. One advantage to ESSPMs over single species production models without biological covariates is that these models can be used to test the existence and direction of (one-way) species interactions. However, estimates of actual interaction strengths are confounded with scaling of the covariates (i.e., catchability). In addition, biological reference points (BRPs; e.g., maximum sustainable yield, MSY) that can be calculated in ESSPMs may be of limited value compared to those estimates that more directly incorporate species interactions because of a lack of feedback between prey and predator species in ESSPMs. We thus developed a full multispecies production model (MSPM) to estimate biological interaction strengths and examine tradeoffs in multispecies MSY. As a preliminary demonstration, we fit this model to functionally analogous cod and herring species for the eastern Bering Sea. We compared results from the MSPM with those from ESSPMs that examined the same species grouping. Estimated species interactions from the two approaches were consistent regarding significance and direction; in contrast, the two approaches produced different MSY estimates. Future work will be to apply the MSPM to functionally analogous cod and herring species across multiple large marine ecosystems in the northern hemisphere. At this point, the answer to the question posed in the title is a qualified "yes", but the tradeoffs between modeling approaches to estimating BRPs for cases where biological interactions are known to be important merit further examination before use in a fisheries management context.

By William Stockhausen

Fisheries Interaction Team (FIT) Staff Conduct Successful Atka Mackerel Tag Recovery Cruise in the Aleutian Islands

The objective of our tag release-recovery studies is to determine the efficacy of trawl exclusion zones as a management tool to maintain prey abundance/availability for Steller sea lions at local scales. Trawl exclusion zones were established around sea lion rookeries as a precautionary measure to protect critical sea lion habitat, including local populations of prey such as Atka mackerel. Localized fishing may affect Atka mackerel abundance and distribution near sea lion rookeries. Tagging experiments are being used to estimate abundance and movement between areas open and closed to the Atka mackerel fishery.

This study is an ongoing research effort. From 1999 to 2006, approximately 80,000 tagged fish were released during NMFS chartered tag release cruises near Seguam Pass, Tanaga Pass, Amchitka Island, and Kiska Island. In May to June 2011 a cooperative venture between the North Pacific Fisheries Foundation and NMFS released approximately 8,500 tagged fish near the Seguam Pass area, 9,000 fish at Tanaga Pass, and 10,000 at Petrel Bank (Fig. 2).

This cruise had three objectives. The first objective was to recover the previously tagged fish in the open areas outside the trawl exclusion zones. Even though tags were released inside the closed areas, during the current recovery cruises in 2011, recoveries were not conducted inside the trawl exclusion zones to minimize potential negative impacts of Atka mackerel removal to the Steller sea lion prey fields inside the closed areas. The second objective of the study was to use catch composition data from these tows to estimate relative abundance indexes (CPUEs) for all major fish and invertebrate species present in the study areas. The third objective was to characterize Atka mackerel habitat and develop methods for estimating indices of abundance of SSL prey species with non-extractive methods such as camera tows.

During the cruise we conducted 73 hauls and examined 1,510 t of Atka mackerel for tags, which is equivalent to approximately 2.6 million individual fish. We recovered 110 wild tags; 10 at Seguam Pass, 86 at Tanaga Pass, and 24 at Petrel Bank, all of which were released during the 2011 tag release charter. All hauls were sampled for species composition and sexed length frequencies. In addition we collected 490 biological samples such as stomachs, gonads, and age structures and obtained sexed length frequencies from 6,805 individual fish. Length distribution of Atka mackerel differed by area with the smallest fish at Petrel bank, medium sizes at Tanaga Pass, and the largest fish at Seguam Pass (Fig. 3).

In order to examine the habitat and develop indices of abundance, we conducted 14 underwater tows with a portable underwater camera (Figs. 4 and 5). We conducted the camera tows at the same locations as the tag recovery hauls. We were able to conduct five camera tows at Seguam Pass, three camera tows at Tanaga Island, and six camera tows at Petrel Bank.

Further analysis will be conducted to estimate population sizes of Atka mackerel in these study areas, understand relative abundance of other SSL prey species and invertebrates, and habitat types associated with those populations.

By Susanne McDermott

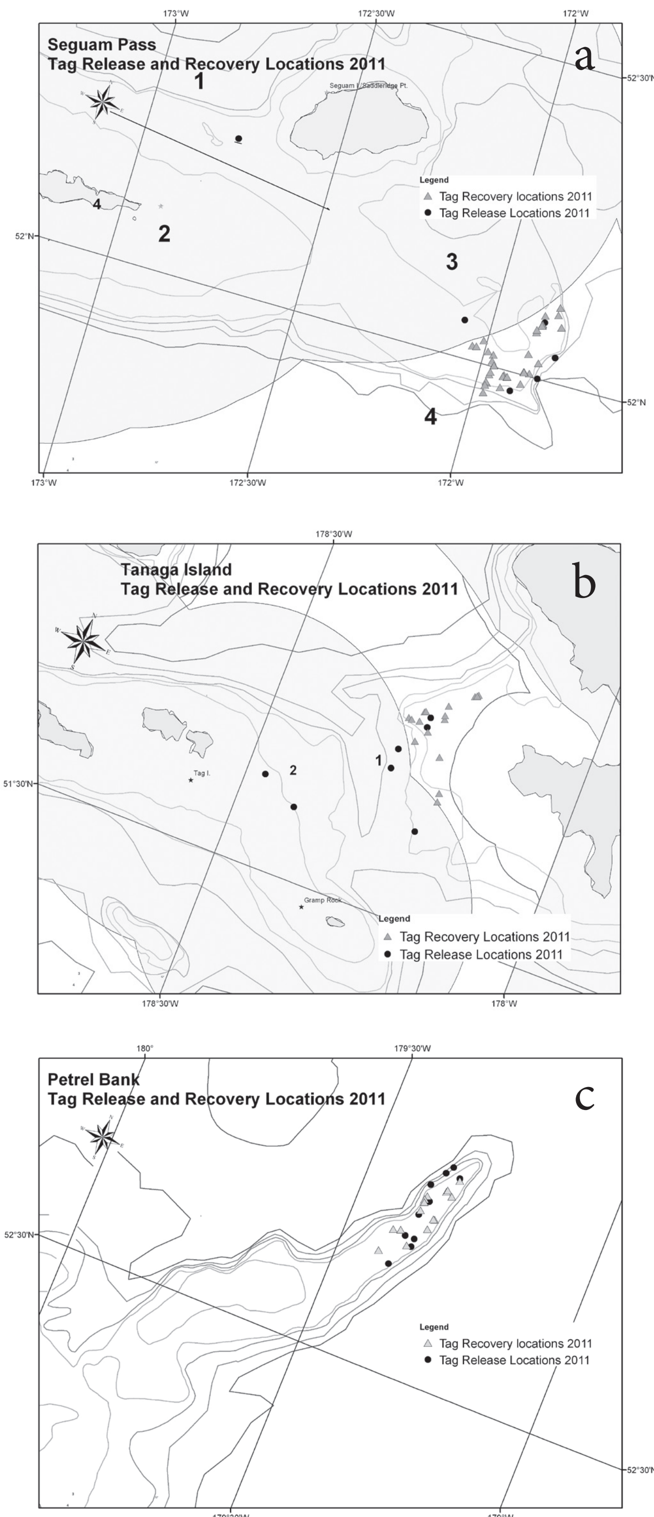


Figure 2. Atka mackerel tag release and recovery locations, 2a. Seguam Pass, 2b. Tanaga Island, 2c. Petrel Bank.

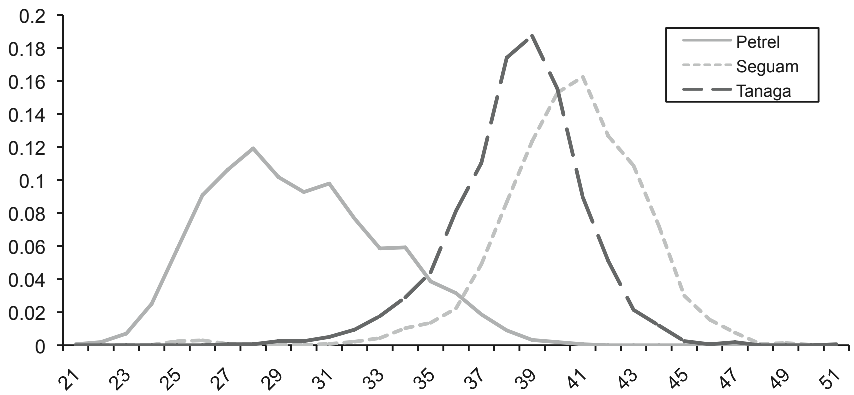


Figure 3. Length Frequency distribution in the three study areas. Solid line: Petrel Bank, Large stippled line: Tanaga Island, small stippled line: Seguam Pass.

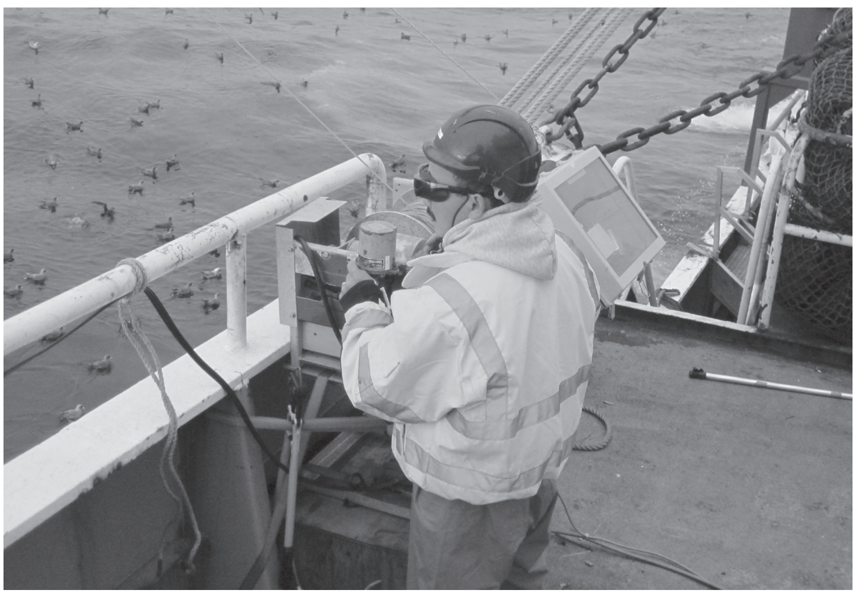


Figure 4. Phil Dang operates the underwater camera while watching the underwater image in video goggles.

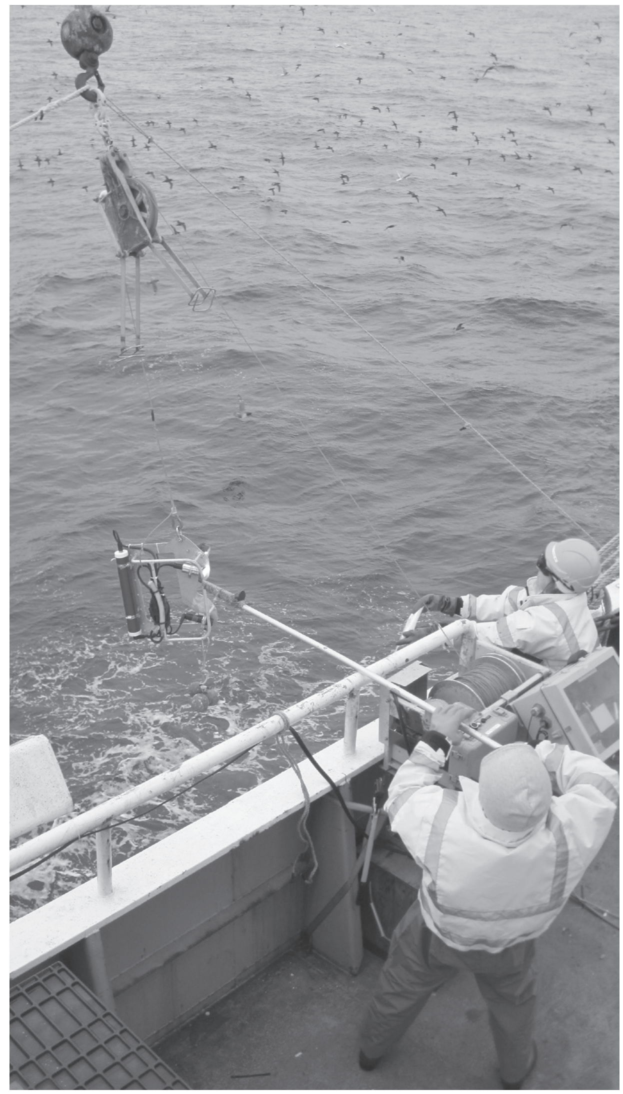


Figure 5. Susanne McDermott and Phil Dang retrieve the underwater camera.

Age & Growth Program

Age and Growth Program Production Numbers

Estimated production figures for 1 January – 30 September 2011. Total production figures were 28,933 with 6,097 test ages and 288 examined and determined to be unageable.

Species	Specimens Aged
Alaska plaice	448
Atka mackerel	993
Blackspotted rockfish	23
Dusky rockfish	672
Flathead sole	2,089
Great sculpin	149
Greenland turbot	1,468
Kamchatka flounder	24
Northern rock sole	1,068
Northern rockfish	1,760
Pacific cod	1,976
Pacific ocean perch	1,757
Plain sculpin	176
Rex sole	910
Rougheye rockfish	533
Sablefish (black cod)	2,361
Shortraker rockfish	19
Southern rock sole	415
Walleye pollock	10,100
Yellow Irish lord	618
Yellowfin sole	1,374

By Jon Short

International Affairs & Research Collaboration

Encounter Protocols on Vulnerable Marine Ecosystems

The North Pacific Fisheries Commission (NPFC) is developing encounter protocols to protect vulnerable marine ecosystems (VMEs) from fishing activities over seamounts in its Convention area. Dr. Loh-Lee Low of the AFSC has been designated the lead to develop the protocols for the Commission. These protocols are required to implement conservation measures to protect VMEs under "International Guidelines for the Management of Deep-sea Fisheries in the High Seas" that were developed by the Food and Agriculture Organization of the United Nations (FAO). The guidelines were developed to implement the United Nations General Assembly (UNGA) Resolution 61/105 that was passed in December 2006. This Resolution calls on States to directly, or through Regional Fisheries Management Organizations and Arrangements (RFMO/A), apply the precautionary approach and ecosystem approach to sustainably manage fish stocks and protect VMEs.

The VMEs over seamounts in the North Pacific Ocean have been designated by the NPFC for protection from significant adverse impacts. The Commission formed a work-group of the member's scientists to look into the following tasks:

1. Determine the distribution of encounters in fishing and survey operations with the four orders of corals identified in the NPFC interim measures as primary indicators of VMEs. (These orders are *Alcyonacea, Antipatharia, Gorgonacea, and Scleractini.*)
2. Estimate catch rates of corals brought up by the fishing gear.
3. Estimate catch rates of corals encountered but not brought up by the fishing gear.
4. Estimate catch rates encountered in directed fisheries on corals and catch rates of encounters not brought up by the fishing gear.
5. Compare the estimated catch rates with those rates encountered in the North Atlantic Fisheries Organization area and the scientific literature, taking into account differences in physical characteristics of the ecosystems and differences in physical characteristics of the ecosystems and differences in fishing gear dynamics.

To prepare for the Commission's assignment, the AFSC organized a working group of NMFS scientists who met in Honolulu during 14-15 September 2011 to review the issues and make recommendations on encounter protocols. Experts from the following NMFS units participated – the Pacific Islands Fisheries Science Center, the Pacific Islands Regional Office, the Alaska Fisheries Science Center, the Northwest Fisheries Science Center, the Southwest Fisheries Science Center, and the Science and Technology Office of NMFS headquarters. A report of the workshop will be issued in December 2011.

By Loh-Lee Low

Salmon Summit

Dr. Loh-Lee Low was an invited speaker at the "Salmon Summit," an international symposium co-convened by North Atlantic Salmon Conservation Organization (NASCO) and the International Council for the Exploration of the Sea (ICES) titled "Salmon at Sea: Scientific Advances and their Implications for Management." He presented an overview of the status of salmon in the North Pacific Ocean and trends in marine mortality. The symposium was held in La Rochelle, France, during 11-13 October 2011. One hundred and thirty scientists and managers from around the North Atlantic and from the North Pacific and Baltic regions attended the symposium. The objectives of the symposium were to review recent advances in understanding the migration, distribution, and survival of salmon at sea and the factors influencing them; consider the management implications of recent advances in understanding the salmon's marine life; identify gaps in current understanding and future research priorities; increase awareness of recent research efforts to improve understanding salmon at sea and to encourage support for future research.

By Loh-Lee Low