Auke Bay Laboratories (ABL)

AUKE BAY ANNUAL CLIMATOLOGICAL SUMMARY

Meteorological observations and their summarization in climatological studies are critical for fisheries oceanographers and ecologists. Variations of solar radiation, temperatures, and precipitation drive ocean currents, circulation, and photosynthetic processes which in turn influence the fluctuations of biological populations important to fisheries. Consequently, daily weather observations and the maintenance of these records are important to NOAA's mission and its several components, National Weather Service (NWS), NOAA Fisheries (NMFS), and National Ocean Service (NOS).

Daily weather observations at the Auke Bay Marine Station were initiated in February 1963 as part of the National Weather Service Cooperative Observer Program. The observations include the daily maximum and minimum air temperature, daily precipitation, daily snowfall, and snow on the ground. Sea surface temperatures have been included since 1975. Daily observations are taken at the end of the work day at about 16:30 hrs.

Of these parameters, water temperature is a major factor controlling water movements, density, and stratification, as well as the distribution, recruitment, and physiological responses of fish, invertebrates, and plants. After a sequence of colder than average years, the 2010 sea surface temperatures were very close to the 35-year average (Fig. 1). A series of storms during June and July, accompanied by cloudy days with low solar radiation, broke down the water column stability, thus preventing stratification that would have allowed higher surface temperatures (Fig. 2).

The end result was that despite some exceptionally warm days, June and July had below average sea surface temperatures. The calendar year 2010 was notable for a dry summer and early fall. Overall, 2010 was drier than average (Fig. 3) although the air temperatures were quite close to average (Fig. 4).

By Bruce Wing

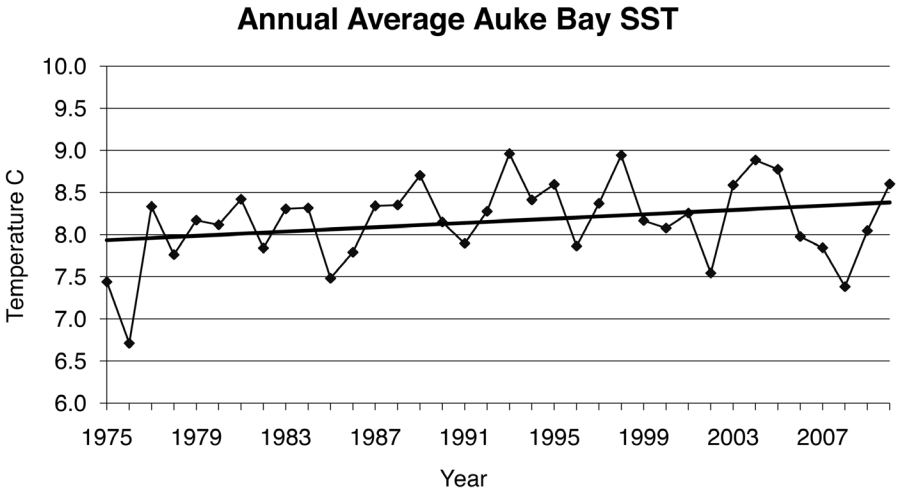


Figure 1. Annual average sea surface temperatures at Auke Bay Marine Station pier, 1975-2010.

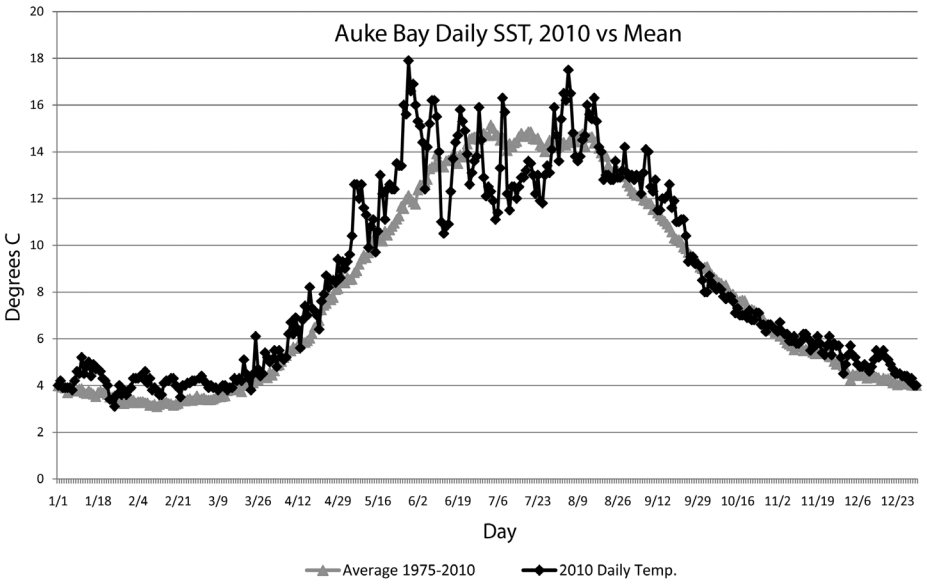


Figure 2. Auke Bay daily sea surface temperature (SST) for 2010 versus the mean.

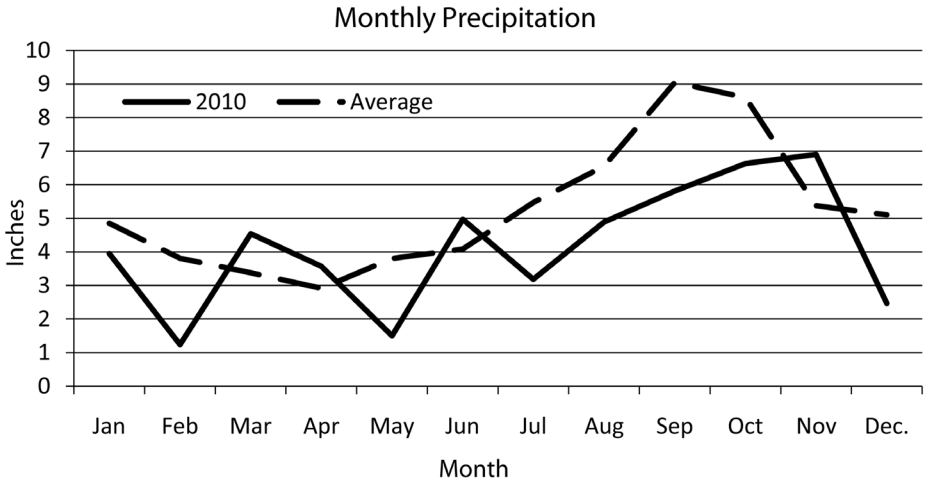


Figure 3. Auke Bay monthly precipitation, 2010 versus the mean.

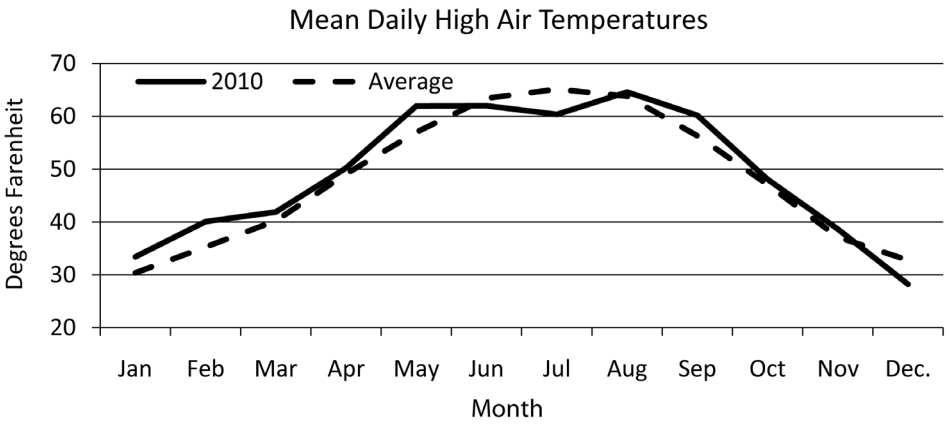


Figure 4. Auke Bay average daily high air temperature for 2010 versus the mean.

MARINE ECOLOGY & STOCK ASSESSMENT PROGRAM

2010 Sablefish Longline Survey

The Alaska Fisheries Science Center (AFSC) has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2010. The survey is a joint effort involving the AFSC's Auke Bay Laboratories (ABL) and Resource Assessment and Conservation Engineering (RACE) Division. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978 to 1994 and also samples gullies not sampled during the cooperative longline survey. In 2010, the thirty-second annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Aleutian Islands was conducted. One hundred-fifty-two longline hauls (sets) were completed from 25 May to 28 August 2010 aboard the chartered fishing vessel *Alaskan Leader*. Sixteen kilometers of groundline were set each day, containing 7,200 hooks baited with squid.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), shortspine thornyhead (*Sebastolobus alascanus*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*). A total of 84,343 sablefish were caught during the survey. Sablefish, shortspine thornyhead, Greenland turbot (*Reinhardtius hippoglossoides*), spiny dogfish (*Squalus suckleyi*), and lingcod (*Ophiodon elongates*) were tagged and released during the survey. Length-weight data and otoliths were collected from 2,203 sablefish. Killer whales (*Orcinus orca*) took significant numbers of fish from the longline at three stations in the Aleutian Islands region, one station in the western Gulf of Alaska, and one station in the central Gulf of Alaska. Sperm whales (*Physeter macrocephalus*) were often present during haul back and were observed depredating on the longline at six stations in the East Yakutat/Southeast region, two stations in the West Yakutat region, and two stations in the central Gulf of Alaska.

Several special projects were conducted during the 2010 longline survey. Lingcod and spiny dogfish were tagged with archival temperature/depth tags in the West Yakutat and central Gulf of Alaska regions. Photographs of sperm whales observed during the survey were taken for contribution to the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) sperm whale catalog. Beginning in 2010, spiny dogfish lengths by sex were included as part of the standard length collections. A new electronic data collection system was tested using handheld data loggers to record catch at the rail, and fish lengths were collected using the existing barcode system integrated with new handheld data loggers. With several refinements the system is expected to be deployed again in 2011.

By Chris Lunsford

Longline Survey Database, Website, and Video

The AFSC conducts annual longline surveys to estimate the relative abundance of major groundfish species, especially sablefish, on the continental slope of the eastern Bering Sea, Aleutian Islands, and the Gulf of Alaska. Recently, a SQL Server database was developed at ABL to house and manage this extensive longline survey data set, which extends back to 1978. Summarized catch and population indices from the longline survey are available to the public on the AFSC website at http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_lsd.htm. For detailed data, requests can be sent to Cara Rodgveller at ABL's MESA Program.

A short video describing the longline survey was created for use as an outreach tool on the AFSC website, YouTube, and in the entrance lobby of ABL's Ted Stevens Marine Research Institute facility. This video can be viewed at http://www.afsc.noaa.gov/ABL/MESA/mesa_sfs_ls.php.

By Cara Rodgveller

Rougheye and Blackspotted Rockfish Species Identification Experiment

The rougheye rockfish was recently split into two species, rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*S. melanostictus*). The presence of a second species was established through genetic analysis and formally verified in 2008. However, a series of field identification experiments since 2005 have led scientists to be concerned about their ability to accurately distinguish between the two species during surveys. The high at-sea misidentification rates from these experiments prompted a special project on the 2009 AFSC GOA bottom trawl survey. The goal of the project was to collect relevant biological and genetic data to improve at-sea identification and examine differences in life history characteristics between the two species. Field scientists collected length, weight, and muscle tissue from most rougheye and blackspotted rockfish being sampled for ages.

Genetic samples and age structures (otoliths) were collected from a total of 934 rougheye and blackspotted rockfish during the 2009 GOA bottom trawl survey. Of these, 495 were identified in the field as rougheye, 420 as blackspotted, and 19 as unidentified rougheye/blackspotted. During the summer of 2010, otolith samples from this project were aged by members of the AFSC Age and Growth Program, and the genetic samples were analyzed by scientists at the ABL's genetics lab. Analysis of these samples indicated that 66% of blackspotted rockfish were correctly identified, and 91%

of rougheye rockfish were correctly identified. Combining this genetic information with the age data will allow for estimation of biological parameters such as growth and distribution by species. In the future, we plan to extend this sampling to commercial fisheries as a special project requested of the Observer Program. When combined with accurate species-specific catch and survey data, such information will help determine whether one species is a weaker stock and may be at greater risk of overfishing.

By S.Kalei Shotwell, Jay Orr, Jon Heifetz, Mark Wilkins, Tony Gharrett, and Sharon Wildes

Recompression Experiments on Rougheye Rockfish with Barotrauma

Because rockfish (Sebastes spp.) are physoclystic (i.e. their gas bladders are closed off from the gut), they often suffer internal injuries from rapid decompression when caught. If these fish are brought to surface by fishermen and then discarded, many do not survive either because they cannot submerge due to excessive buoyancy or because of internal damage caused by rapid gas expansion during ascent. There is some evidence that recompression may greatly increase the survival of barotrauma-injured rockfish. However, survival can be species-specific, and it is therefore important to gauge the impacts of rapid decompression on each species of interest.

Research completed at ABL in 2010 demonstrated that rougheye rockfish, (*Sebastes aleutianus*) caught at depths greater than 700 feet and exhibiting severe barotrauma could survive if recompressed immediately after capture with portable pressurized tanks. These 12"x42" tubular tanks were constructed in-house and adapted from a design described by Jeff Smiley at Hubbs SeaWorld. They are small and light enough to be transported by hand when empty and with a crane or on a hand-truck when full of water. This result is noteworthy because it is the deepest known successful capture and recompression of any rockfish species, and it opens the door for future scientific tagging studies to track movements and behavior of deepwater rockfish. Objectives are to tag captured rougheye and shortraker rockfish and rapidly recompress them by dropping them back to depth. Fish will also be recompressed with portable pressure tanks for estimates of survival of tagged fish.

By Cara Rodgveller, Chris Lunsford, and Pat Malecha

Groundfish Stock Assessments

This quarter, scientists from ABL's MESA Program completed three full stock assessments and five updated assessments for eight species/species groups of Alaska groundfish. Full assessments included Alaska sablefish, Bering Sea/Aleutian Islands sharks, and Gulf of Alaska sharks. Short stock assessment updates included Gulf of Alaska Pacific ocean perch, northern rockfish, rougheye/blackspotted rockfish, pelagic shelf rockfish, and shortraker rockfish and "other slope rockfish". An unofficial full assessment was also done for Alaska grenadiers because in the future they may become managed species that will require a stock assessment.

For the rougheye/blackspotted rockfish assessment, a stock structure analysis was completed, and it was determined that the structure was reasonably consistent with current management units. A review of factors affecting sablefish recruitment was written and presented at the request of the North Pacific Fishery Management Council (NPFMC). Stock Assessment and Fishery Evaluation (SAFE) reports or executive summaries were prepared for each assessment, and results were presented to the NPFMC's Groundfish Plan Teams in November and also reviewed by the Council's Scientific and Statistical Committee in December. The Council used these assessments as the primary source for determining catch quotas (levels of Total Allowable Catch) for these species in 2011.

For detailed information about these assessments, see the Status of Stocks & Multispecies Assessment Program's article "Groundfish Stock Assessment for 2011: Fishery Quota Recommendations" ticle in the Resource Ecology and Fishery Management (REFM) Division section of this issue of the AFSC *Quarterly Report.*

By Dave Clausen

Estimation of Bycatch in the Halibut Fishery

The Pacific halibut longline fishery makes up an important part of the total fishing effort in the Gulf of Alaska and Bering Sea/Aleutian Islands regions. This fishery is managed separately from other groundfish fisheries by the International Pacific Halibut Commission (IPHC), and as such, the boats do not fall under the same fishery observer requirements as other groundfish vessels. Because of this lack of observer coverage, scientists have no knowledge of the quantities of other species that are caught and discarded (bycatch) in the halibut fishery; however, the reauthorized Magnuson-Stevens Fishery Conservation and Management Act requires that all sources of removals be accounted for in future stock assessments.

The NPFMC has approved the restructuring of observer coverage, which will include placing observers on much of the halibut fleet. These changes will not take effect until 2013, but it is necessary to have estimates of catch for current assessments and the ability to look at the historical bycatch in the halibut fishery. A working group was formed in January 2010 to explore methods to estimate bycatch of species such as sharks, skates, and Pacific cod in the unobserved halibut fishery. This working group is composed of scientists from the AFSC, NMFS Alaska Regional Office, IPHC, and Alaska Department of Fish and Game (ADF&G).

A variety of quantitative methods are under investigation by the working group. The IPHC conducts a longline survey each year, which covers much of the Gulf of Alaska and Bering Sea/Aleutian Islands. Efforts have been made in past stock assessments to account for bycatch in the halibut fishery, in some cases using vastly different approaches, but all using the survey data as a proxy for actual observer data. The two main questions are: how do you treat the survey data to make it accurately reflect commercial effort; and what is the best way to extrapolate the survey data to total commercial effort?

The working group has examined previously-used methods as well as developed new approaches. The NPFMC Groundfish Plan Teams reviewed the various methods presented by the working group, and the recommended method will be further reviewed by the NPFMC's Scientific and Statistical Committee in February 2011. Catch estimates based on these methods are expected to be available for the 2011 assessment cycle.

By Cindy Tribuzio

Workshop on Deep-Sea Coral Research in Alaska

The AFSC hosted a workshop in Anchorage, Alaska, on 14-15 September 2010, as part of NOAA's Deep Sea Coral Research and Technology Program. The goal of the workshop was to develop a 3-year exploration and research action plan for deep-sea corals and sponges in Alaska that addresses resource management needs. Program funding is expected to be available for research in Alaska beginning in 2012. Twenty scientists, managers, and resource stakeholders attended the 2-day workshop. A workshop report is in preparation and will be available in March 2011. The workshop steering committee included Robert Stone (chair, AFSC Auke Bay Laboratories), John Tomczuk (NOAA Oceanic and Atmospheric Research), Jennifer Reynolds (University of Alaska Fairbanks & NOAA Oceanic and Atmospheric Research), John Olson (NMFS Alaska Regional Office), and Dave Witherell (North Pacific Fishery Management Council).

By Bob Stone

Figure 5. Researchers process a large catch of juvenile salmon from a 20-minute surface trawl haul 4 miles offshore in Icy Strait, June 2010. Photo by Molly Sturdevant.

ECOSYSTEM MONITORING & ASSESSMENT PROGRAM

Southeast Coastal Monitoring Pink Salmon Harvest Forecast Models: Accurate for 2010 and Predicting a Strong Harvest for 2011

Fourteen years ago ABL launched the Southeast Alaska Coastal Monitoring (SECM) project to study the effects of marine ecosystem dynamics on salmon recruitment in Southeast Alaska (SEAK). This annual fisheries and oceanographic survey has been conducted during the months of May to August in inside waters of SEAK utilizing government and chartered vessels. Fishes, including juvenile salmon, Pacific herring, and walleye pollock are collected using surface trawls; oceanographic measurements include zooplankton biomass, conductivity-temperature-at depth, and surface nutrients and chlorophyll-a. The extended time series of annual SECM ecosystem metrics offers a unique opportunity to determine the effect of climate change and variability on marine ecosystems in SEAK.

One of the major objectives of these SECM annual surveys is to reduce uncertainty in pink salmon forecasts for SEAK. Pink salmon is a vital component of the commercial fishery in Alaska providing an average ex-vessel commercial value of $24 million to the SEAK economy from 2005 to 2010. Reducing uncertainty in salmon forecasts increases economic benefits to Alaska fishers and communities and also helps maintain biological sustainability of the salmon resource for future generations. Determining the appropriate metrics to include in salmon forecasts is not an easy task, and many of the current salmon forecast models do not capture the high variability in adult returns. This uncertainty in salmon forecast models has lead to a number of economic disaster declarations for Alaska in the past two decades, emphasizing the need for research efforts that examine marine ecosystem metrics that can help explain salmon recruitment.

Pink salmon, which have a simple 2-year life cycle, are notoriously difficult to forecast because unlike most other salmon species they lack leading indicator data necessary to construct sibling forecast models. Despite this lack of leading indicator data, SECM pink salmon forecasts have successfully predicted harvests within 8% of the actual annual harvests in SEAK (12-59 million) during 6 of the past 7 years by relying upon marine ecosystem metrics. SECM surveys (Fig. 5) have determined that the peak abundance of juvenile pink salmon during either June or July is one of the primary metrics explaining future pink salmon returns to SEAK. However, forecast model accuracy has also been improved in some years by adding oceanographic parameters such as regional May water temperature or later ocean basin index parameters such as the El Niño/Southern Oscillation Index (ENSO); these auxiliary parameters are believed to affect salmon early marine growth, condition, and marine survival.

Last year the SECM forecast model for 2010 predicted a harvest of 26.8 million fish, very close to the actual 24.2 million fish harvested that year. The SECM forecast model used to predict the 2010 harvest was a stepwise regression model using the factors of log normal-transformed peak juvenile pink salmon catch per unit effort (CPUE), May integrated temperatures in the upper 20 m waters of Icy Strait, and the ENSO Index lagged to the juvenile ocean entry year. For 2011, the SECM forecast model predicts a large harvest of 56.2 million pink salmon, more than double the harvest realized in 2010. The SECM forecast model used for the 2011 harvest year is based solely on juvenile pink CPUE.

The SECM research has been supported over the years by federal and state agencies through the Pacific Salmon Commission (Alaska Sustainable Salmon Fund or Northern Fund), and SECM researchers provide annual pink salmon forecasts at the Southeast Alaska Purse Seine Task Force (PSTF) meetings soon after the commercial salmon fishing season. The PSTF meetings are co-sponsored by the ADF&G and the Southeast Alaska Seiners Association and are held rotationally in Juneau, Ketchikan, Petersburg, or Sitka. The PSTF meetings are

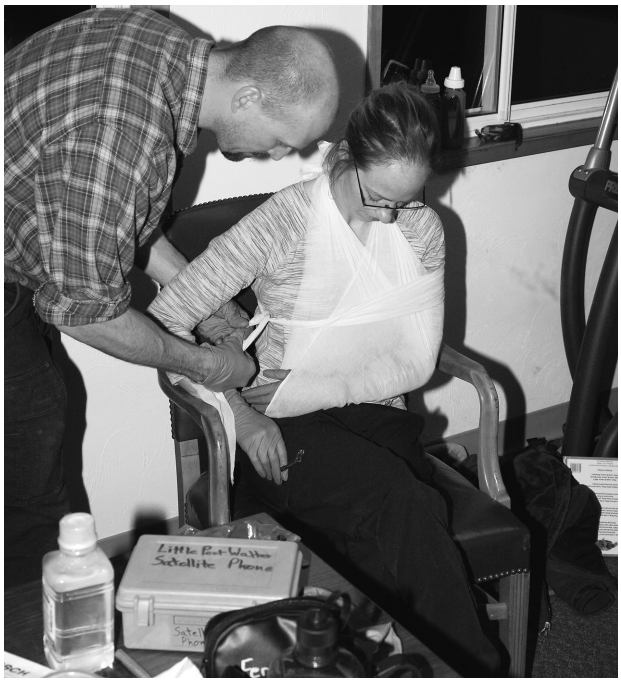


Figure 6 (top). Personnel of Little Port Walter Marine Station completed the State of Alaska's Emergency Trauma Technician training. Picture above: Angela and Scott Feldmann practice pediatric immobilizing and transport with their daughter Lillian. Figure 7 (right). Tommy Abbas splints Theresa Abbas's arm. Photos by Scott Fergusson.

attended by commercial salmon fishermen, industry processors, ADF&G managers and researchers, private non-profit salmon aquaculture associations, and the general public.

Marine ecosystems are complex and difficult to understand, but the SECM research has shown that systematic sampling done on an annual basis can be applied to better understand mechanisms responsible for salmon recruitment and meet the needs of fishery resource managers and stakeholders.

By Joe Orsi, Molly Sturdevant, Emily Fergusson, and Bill Heard

FISHERY ECOLOGY, DIET, & ZOOPLANKTON PROGRAM

Residents at Little Port Walter Marine Station Receive Emergency Trauma Technician Training

Little Port Walter Marine Station (LPW) is an isolated research facility located on southeast Baranof Island, 52 miles southeast of Sitka, Alaska, and 110 miles south of Juneau. Two permanent employees are stationed at LPW. They, along with their families, live year round at LPW and are joined by as many as 20 researchers and support staff between May and October. The geography, weather, and vast distance between LPW and the closest medical facility make the logistics of emergency medical services a formidable challenge. Making an accurate initial assessment of degree of injury or illness and providing sustained stabilized care to the patient until transport are the two primary concerns when dealing with a medical emergency at LPW. It can take up to several days for a patient at LPW to get to advanced medical care.

To shorten the time between injury and medical care, all adult personnel of LPW completed the State of Alaska's Emergency Trauma Technician (ETT) training. The ETT training is a 44-hour course that was originally designed to provide emergency medical training for people living in remote or rural areas of Alaska. The role of an ETT is to provide first response, initial assessment and basic medical care, prepare patients for transport, and pass the patient on to a more highly trained care provider. Topics covered in the training included provider and patient well being, lifting and moving patients, advanced airway techniques, adult and infant CPR/AED (cardiopulmonary resuscitation/automatic external defibrillator), patient assessment, scene safety, trauma and medical emergencies, pediatric emergencies, environmental emergencies, and oxygen administration (Figs. 6 and 7). The course was taught by Captain Scott Fergusson of Capital City Fire/Rescue and was held at LPW 27-31 December 2010.

By Angela Feldmann

Fisheries Monitoring & Analysis (FMA) Division

A Long Time Coming: North Pacific Groundfish Observer Program Restructure

It's taken 20 years to accomplish but, at its October 2010 meeting, the North Pacific Fishery Management Council (Council) took final action to restructure the North Pacific Groundfish Observer Program (Observer Program). This action provides a huge opportunity for NOAA's National Marine Fisheries Service (NMFS) to make some needed Observer Program sampling design improvements and to expand observer coverage into currently unobserved fisheries. While implementation of the new program will be challenging, the result will be improved fisheries-dependent data for NOAA and the Council and will address a longstanding recommendation of the Department of Commerce Inspector General.

Under the approved Council action a variety of longstanding issues will be addressed. All sectors of the groundfish fishery including vessels less than 60 feet in length and the commercial halibut sector will be included in the program. Further, coverage levels will no longer be based on vessel length and processing volume; rather, NMFS will have the flexibility to decide when and where to deploy observers based on a scientifically defensible sampling design. The design of the new program will serve to reduce sources of bias that cur-

A rare sunny day is captured digitally by a fishery observer onboard a catcher trawler leaving Unalaska Island. Photo by Aidan Hutchins.

rently jeopardize the statistical reliability of catch and bycatch data collected by the Observer Program.

Once the new program is implemented, all vessels and processors in the groundfish and halibut fisheries off Alaska will be placed into one of two observer coverage categories established in regulation: the "less than 100 percent" (<100%) coverage category and the "greater than or equal to 100%" (≥100%) coverage category. Observer coverage for vessels and processors in the <100% coverage category will be managed under an ex-vessel fee-based observer service delivery model. Vessels in this category will be assessed a 1.25% fee on the ex-vessel value of the landed catch weight of groundfish and halibut. The money generated by these fees will provide the funding available for deployment of observer coverage on this restructured portion of the fleet. The fee percentage, which will be set in regulation, will be reviewed annually by the Council after the second year of the program. Vessels and processors in the ≥100% coverage category will continue to obtain observers by contracting directly with observer providers ("status quo") and will not be included under the ex-vessel fee-based restructured program.

Start-up funds will need to be available to NMFS to begin implementation of the restructured portion (<100% coverage category) of the program. The NMFS Alaska Region will continue to seek federal funding for start-up costs of implementation of the restructured Observer Program. Lacking federal start-up money, NMFS will collect fees in addition to existing observer expenses in a given year, from the restructured portion of the fleet for 1 year ("year 0") to build enough money to begin implementation.

During the October meeting, the Council also notified the public that the Observer Advisory Committee will be reconstituted to respond to its new focus of 1) helping to resolve implementation issues that arise during the development of the proposed rule; and 2) developing electronic monitoring for specific sectors. The new Chair of the OAC is Dan Hull, and the Council is looking to fill the committee primarily with representatives of those included in the restructured program, and/or with experience and interest in electronic monitoring.

The projected timeline for implementation of the restructured Observer Program is dependent on several steps, many of which are now associated with the rulemaking process and Federal contracting process. Based on the size and complexity of each of these steps, implementation of a newly restructured Observer Program is not expected to occur until 2013.

The full text of the motion which passed unanimously 11-0 can be found on the Council website at www.fakr.noaa.gov/npfmc/current_issues/observer/ObserverMotion1010.pdf. The full text of the analysis (EA/RIR/IRFA) for restructuring the program for observer procurement and deployment in the North Pacific can be found on the Council website www.fakr.noaa.gov/npfmc/current_issues/observer/Observer_restructuring910.pdf

By Patti Nelson

NATIONAL MARINE MAMMAL LABORATORY (NMML)

ALASKA ECOSYSTEMS PROGRAM

First Winter Capture and Tracking of Adult Female Steller Sea Lions in Southeast Alaska

In November 2010, three adult female Steller sea lions (*Eumetopias jubatus*) were successfully captured and handled in Southeast Alaska, the first time adult female Steller sea lions have been captured, tagged, and subsequently tracked using satellite telemetry in Southeast Alaska in the winter. This successful project resulted from a collaboration of researchers—from the Alaska Ecosystems Program (AEP), Alaska Department of Fish and Game, and Vancouver Aquarium—who developed techniques that will be used in new studies to address critical Steller sea lion and commercial fishery management research needs in the western and central Aleutian Islands.

Understanding where marine mammals forage to obtain energy needed for growth and reproduction is necessary to evaluate the potential for competition with other predators (including humans) for resources and is a fundamental requirement for informed ecosystem-based fisheries management. In the Aleutian Islands where Steller sea lions are listed as an endangered species, very little is understood of adult female sea lion foraging behavior outside of the June-July breeding season when most foraging trips occur close to rookeries. Where adult females access prey resources to maintain pregnancy during winter is one of the fundamental questions central to understanding whether commercial groundfish fisheries have indirect impacts on those sea lion populations. However, the minimal information on adult female foraging be-

havior in winter comes from only six adult females captured in the eastern Aleutian Islands through the eastern Gulf of Alaska in 1990-96.

Because of their size and behavior, the method of choice for capturing adult female Steller sea lions has been through the use of sedatives delivered with darts fired from rifle-like dart-projectors. In Alaska, limited numbers of adult females were captured using this method during the 1990s; but because their unique otariid physiology limited sedative drug options, and their haul-out location on rocky sites in close proximity to water encouraged water entry prior to sedation, these captures were associated with a high mortality risk. As research attention became focused on understanding juvenile sea lion foraging ecology and health status, underwater capture techniques perfected during the 2000s greatly increased the number of juvenile sea lions that could be safely captured and handled, but this technique was only successful with animals less than 4 years old. For our study, we built on the recent success of a California sea lion study—by researchers from the NMML California Current Ecosystems Program, Vancouver Aquarium, and Marine Mammal Center—that utilized a novel combination of sedatives. In contrast to previously used sedatives, this new combination appears to be well tolerated by sea lions and is quickly reversible through the administration of reversal drugs.

The objective of our study was, thus, to perfect techniques to allow safe capture and handling of adult female Steller sea lions and to apply state-of-the-art tracking instrumentation and sampling techniques to assess foraging behavior and health status and condition. Our team of nine researchers (including two veterinarians) used the chartered vessel *Norseman* to attempt captures at three locations: Benjamin Island in Lynn Canal and Southwest Brothers Island and Sail Island in Frederick Sound (Fig. 1). Of six adult females darted, three were captured and handled. Two were sedated within 10 minutes on land at the point of capture, and a third entered the water but returned to shore prior to sedation. All three sedated animals were transferred to inhalable anesthesia, and multiple samples and measurements were collected to assess their health status and condition. Each

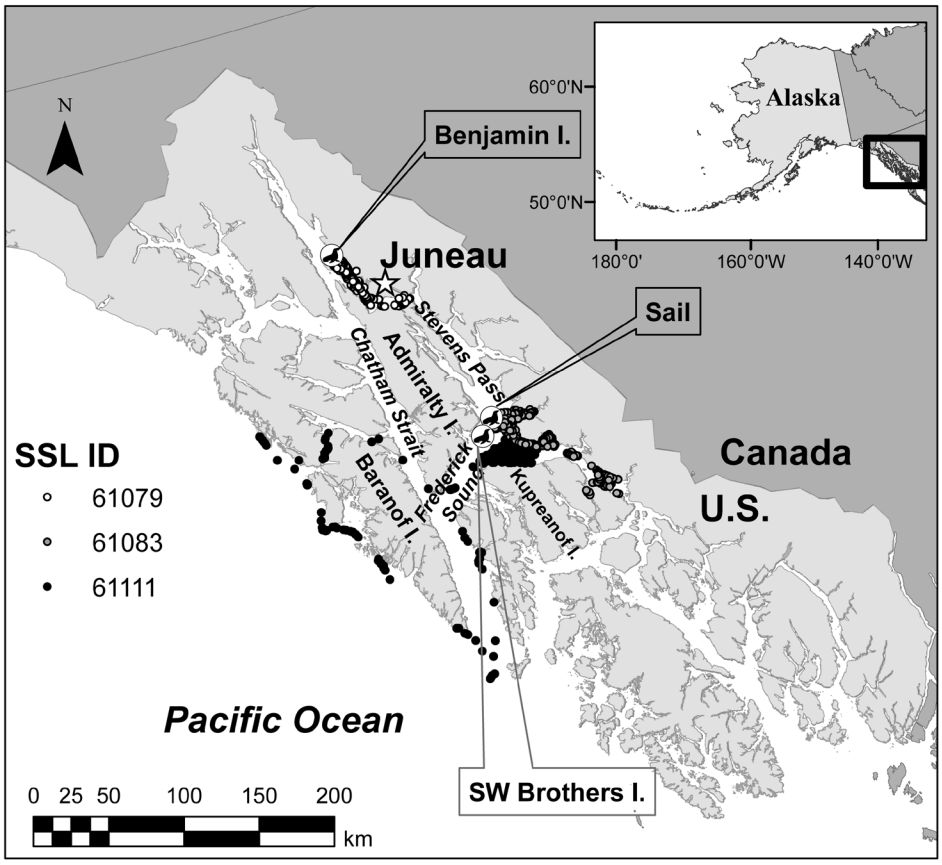


Figure 1. Locations of November 2010 captures of three adult female Steller sea lions and their subsequent at-sea GPS locations through early January 2011.

was outfitted with a Mk10-AF fast-location GPS/Argos-location and dive-recording transmitter manufactured by Wildlife Computers (Redmond, WA). All three rapidly and fully recovered from sedation after injection with reversal agents. Three other sea lions were darted but moved into the water within minutes. In a distinct difference from studies in the 1990s, however, we were able to locate, follow, and confirm survival of all three animals from a skiff. Two animals were followed for over an hour and were observed to fully recover from the sedation effects. The third was followed, given reversal agents via dart injection while in the water, and then rapidly swam away from the skiff; this animal was subsequently observed hauling out on land fully recovered.

Because no adult female Steller sea lions have previously been tracked in Southeast Alaska during winter, these data will provide new insights into how mothers with dependent pups navigate and forage in these waters. Locations determined from GPS positions transmitted via Argos over the first 60 days of deployment show distinctly different behaviors associated with habitat use in Southeast Alaska among the three sea lions (Fig. 1). In contrast to data collected in summer, when adult females are constrained to provisioning newborn pups and typically undertake foraging trips within 20 nautical miles (nmi) of rookeries, data from these three females show that sea lions travel much greater distances and utilize much more habitat in winter. Sea lion 61079 captured at Benjamin Island has spent most of her time within Favorite Channel, with some forays into Stephens Passage. The two sea lions captured at haulouts less than 15 km apart in Frederick Sound displayed contrasting movements. Sea lion 61083 from Sail Island spends most of her time in southern Stephens Passage and Port Houghton but has also made two trips down Frederick Sound to the Petersburg area and spent some time in Wrangell Narrows. In contrast, sea lion 61111 captured at Southwest Brothers Island has mostly moved between that location and various other haulouts in

Frederick Sound near Kupreanof Island. But this sea lion also undertook a longer journey north through Chatham Strait, through Peril Strait to the outer coast, and north to White Sisters (a summertime rookery) before heading south around the southern tip of Baranof Island and back into Frederick Sound.

This pilot study developed methods that will be applied to our planned captures of adult females in the western Aleutian Islands later in 2011. Compared to methods used in studies of adult female Steller sea lions in the 1990s, the new sedative combination used in this study improved capture efficiency and animal safety. Data on adult female foraging behavior in Southeast Alaska and the information on health status and condition obtained in this study will be useful contrasts to data collected from sea lions captured in the western Aleutian Islands.

By Brian Fadely

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

The Long and the Short of It: A Simple Photograph-based Approach for Discriminating between Free-ranging Long-finned and Short-finned Pilot Whales off the East Coast of the United States

Long-finned (*Globicephala melas*) and short-finned (*G. macrorhynchus*) pilot whales look similar at sea. Described pigmentation characters include a post-orbital eye blaze, a post-dorsal saddle patch, and a cape that connects the eye stripe and the saddle. Although these two species are readily distinguishable using osteological characters like tooth counts and skull morphology or by genetic analyses, they are generally considered not to be predictably distinguishable at sea by physical characteristics. In some areas (e.g., the western North Atlantic), their ranges overlap, thus, this difficulty in identifying individuals to species limits at-sea studies.

In the western North Atlantic, long-finned pilot whales have an anti-tropical distribution with a southern limit of North Carolina, and short-finned pilot whales are found in tropical waters with a northern limit of New Jersey. The shelf edge/slope water region is an important habitat for both species of pilot whales and, in the western North Atlantic, their ranges overlap during summer from approximately 35°N (Cape Hatteras, North Carolina) to 39°N (east of Delaware Bay) (Fig. 2).

Understanding potential anthropogenic impacts (e.g., fisheries) to both species of pilot whales in the western North Atlantic as reviewed in the NMFS stock assessment reports (SARs) is important to properly manage these populations. Their similarity of appearance, significant range overlap, and the inability to distinguish between them during assessment cruises add uncertainty when describing the geographic range, estimating the minimum population size and human-induced mortality and serious injury rates, and calculating the potential biological removal (PBR) level, which is required for each stock. To date, all SARs of western North Atlantic pilot whales are inadequate; species-specific abundance estimates have not been produced due to the uncertainty of species identity within a large proportion of their putative summertime ranges.

In this study, we developed a photograph-based approach to distinguish these two species of pilot whales in the western North Atlantic. We collected and examined photographic images of pilot whales coincident with genetic sampling during five summer research cruises conducted in U.S. waters of the western North Atlantic and from one stranded animal during the years 2004-07. We examined the utility of physical features that are detectable in photographs such as relative shape or coloration as useful discriminating characters.

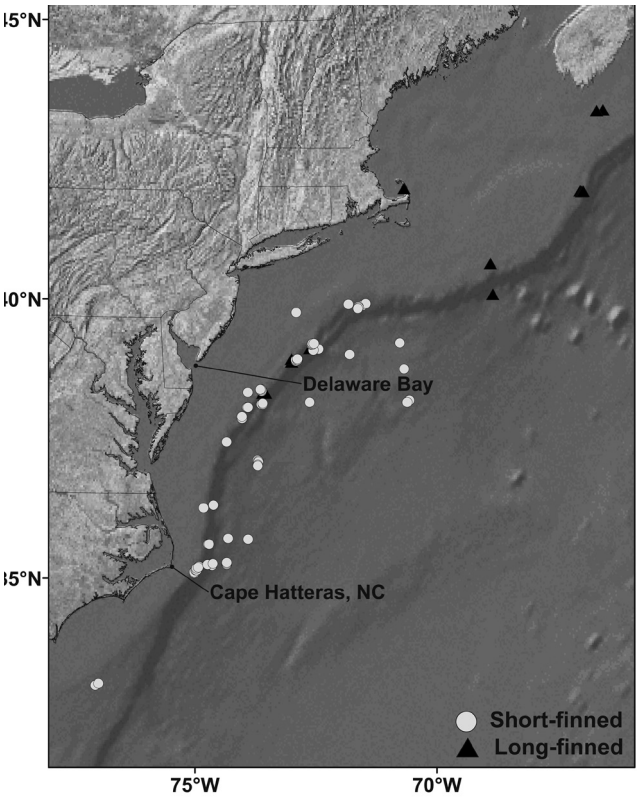


Figure 2. Map depicting the study area, range overlap, and genetic samples collected during the years 2004-07.

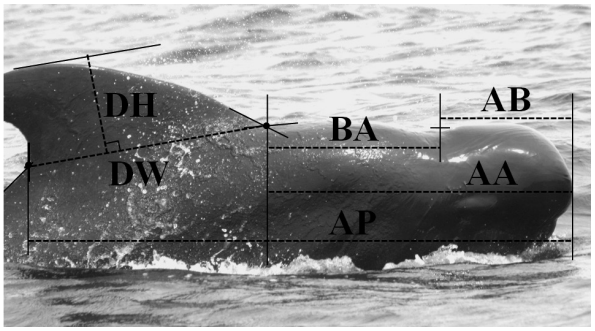


Figure 3. Reference lines (solid lines) used to define the six morphometric features and relative measurements collected (dotted lines) on an image of a free-ranging pilot whale used for species discrimination.

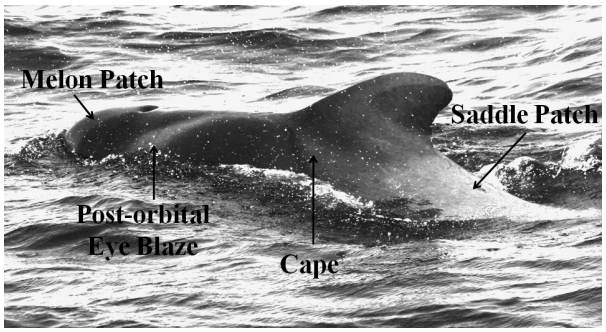


Figure 4. The four categories analyzed for pigmentation. The pilot whale in this example displays the presence of pigmentation in all four areas: melon patch, post-orbital eye blaze, cape, and saddle patch.

For morphometric analyses, 11 combinations of ratios calculated from six morphological features along with a three-level size-class covariate (small, medium, large) accounting for sexual dimorphism and allometric growth rate were used to test discrimination functions for species identification (Fig. 3). Two datasets were analyzed: the training set (non-genetically sampled animals) used to calculate parameter estimation and the validation set (genetically sampled animals; see Fig. 2) used to assess the model's predictive power. The resulting discrimination function equation (± SE) used to predict species identification is:

P (short-finned pilot whale) =
exp (*f*)/ (1 + exp (*f*))(f = function)

f =-63.719(± 10.7)(Large) +
3.104(± 1.4)(Medium) +
6.432(± 1.8)(Small) +
15.897(± 6.0)(AB/BA) +
46.253(± 9.4)(DH/DW) +
44.126(± 8.7)(DW/BA)

Pigmentation was analyzed as presence/absence of four pigmentation characters: melon patch, post-orbital eye blaze, cape, and saddle patch (Fig. 4). All four characters were present in 100% of the short-finned pilot whales, explaining an overall lighter appearance compared to long-finned pilot whales in which melon patch, blaze, and saddle patch were present 6%, 68%, and 50%, respectively, and the cape was completely absent (Figs. 5a, b).

As a result of this study, two procedures were designed to identify pilot whales at sea in the western North Atlantic under varying field conditions. If a sighting event occurs during sufficient daylight and the lighting is such that pigmentation contrast is easily discernable (i.e., sunny conditions and minimal glare) and capturing acceptable images for morphometric discrimination is not possible, analysis of the pigmentation is likely sufficient for determining species. However, during times with difficult lighting conditions (i.e., glare, sunrise, sunset, or overcast), a morphometric analysis should be applied. To achieve the most accurate species identification, the two approaches should be used together to provide multiple pieces of evidence for determining the species identity.

Figure 5a (top). Classic pigmentation characteristics on two short-finned pilot whales: melon patch, blaze, cape, and saddle patch extending from the cape down the dorsal caudal peduncle; 5b (bottom). A long-finned pilot whale displaying both the absence of the cape and a saddle patch with a distinct boundary located just posterior to the dorsal fin.

Until now, many cetacean biologists thought that reliable determinations of pilot whale species could not be made at sea in areas where both species were found. In this study, image utility was explored, image protocols for analysis were defined, and results showed that a species designation for free-ranging western North Atlantic pilot whales was quite reliable when implementing a simple, inexpensive method. This method can easily be incorporated into future cetacean abundance surveys off the East Coast, which could then result in separate abundance estimates of short-finned and long-finned pilot whales.

By Brenda Rone and Richard Pace

POLAR ECOSYSTEMS PROGRAM

Completion of Endangered Species Act Status Reviews for Ringed and Bearded Seals

A Biological Review Team (BRT) convened by NMFS recently completed Endangered Species Act (ESA) status reviews of ringed seals (*Phoca hispida*) and bearded seals (*Erignathus barbatus*) (Figs. 6 and 7). The status reviews were prepared in response to a petition filed by the Center for Biological Diversity seeking to list these species as threatened or endangered under the ESA, primarily due to concern about threats to the species' habitats from climate

Figures 6 and 7. Arctic ringed seal (top) and bearded seal (bottom). Photos by Brendan Kelly and John Jansen.

warming and diminishing sea ice and snow cover. The status reviews were based on assessments of the best available scientific and commercial information concerning the conservation status of the species as well as past, present, and future threats to the species and were intended to support NMFS' decisions of whether threatened or endangered listings were warranted. The BRT was composed of eight marine mammal biologists from the National Marine Mammal Laboratory, the Northeast Fisheries Science Center, and the U.S. Fish and Wildlife Service; a fishery biologist from the AFSC's Resource Ecology and Fisheries Management Division; and a climate scientist and an ocean chemist from NOAA's Pacific Marine Environmental Laboratory.

The BRT's reviews focused on two key tasks. The first key task was delineating the species under consideration. There are currently five recognized subspecies of ringed seals (*P. h. hispida* in the Arctic Ocean and Bering Sea; *P. h. ochotensis* in the Sea of Okhotsk; *P. h. botnica* in the Baltic Sea; *P. h. ladogensis* in Lake Ladoga, Russia; and *P. h. saimensis* in Lake Saimaa, Finland) (Fig. 8) and two recognized subspecies of bearded seals (*E. b. barbatus* in the Atlantic sector of the Arctic and *E. b. nauticus* in the Pacific sector of the Arctic as well as the Bering Sea and Sea of Okhotsk) (Fig. 9). Based on an evaluation of physical, physiological, ecological, behavioral, and international regulatory factors, the BRT determined that delineating the five subspecies of ringed seals into smaller population units was not warranted at this time. The BRT emphasized, however, that further investigation into ringed seal population structure may discern additional units, especially in the Arctic subspecies. The BRT also concluded that subdividing *E. b. barbatus* was not warranted at this time. However, based on evidence of physical discreteness and ecological uniqueness of bearded seals in the Sea of Okhotsk, the BRT delineated *E. b. nauticus* into two distinct population segments (DPS): the Beringia DPS, in the Pacific sector of the Arctic and the Bering Sea, and the Okhotsk DPS in the Sea of Okhotsk (Fig. 9). The Arctic subspecies of ringed seals (*P. h. hispida*) and the Beringia DPS of bearded seals are the only population units occurring within U.S. (Alaskan) waters.

The second key task of the status reviews was to conduct an extinction risk assessment. The BRT reviewed published data, consulted with other experts, and evaluated 17-19 specific threats to the persistence of each subspecies or DPS, grouped by the following ESA factors:

- the present or threatened destruction, modification, or curtailment of its habitat or range;
- overutilization for commercial, recreational, scientific, or educational purposes;
- disease or predation;
- the inadequacy of existing regulatory mechanisms; or
- other natural or man-made factors affecting its continued existence.

The BRT also assessed the risks to each population's persistence posed by those threats in demographic terms (i.e., abundance, productivity, spatial structure, and diversity), at present and in the foreseeable future. Threats and demographic risks were scored quantitatively and the level of certainty in scores was also recorded.

Based on these assessments, the BRT concluded that the modification of ringed and bearded seals' habitats and curtailment of their ranges posed the greatest threats to these species' persistence. Ringed and bearded seals require sea ice as a platform for whelping and nursing their young during the late winter and spring and for molting their coats in late spring and summer each year. Being primarily benthic feeders, bearded seals are also closely associated with highly productive, shallow waters over continental shelves where benthic prey species are accessible. Climate models and other sea-ice analyses used by the BRT projected substantial reductions in March-May ice extents in the Bering, Okhotsk, Barents, and Baltic Seas as well as in Hudson Bay, Lake Ladoga, and Lake Saimaa by mid- to late century. Ice cover in these areas has historically been sparse and variable during June-July and is projected to be even more so in the future. In more northerly seas, there is projected to be little or no decline in ice extent during March-May during this century; moderate declines in June ice cover and substantial declines in July ice cover are, however, projected by the end of this century.

For bearded seals, the loss of ice cover over shallow feeding areas during times of peak whelping and nursing (April-May) or molting (May-July) would force the seals to either seek sea ice over deeper waters (perhaps with poor access to food) or coastal regions in the vicinity of haul-out sites on shore (perhaps with increased risks of disturbance, predation, and competition). Both scenarios would require bearded seals to adapt to novel (suboptimal) conditions and to exploit habitats to which they may not be well adapted, likely compromising their reproduction and survival rates and leading to population declines.

For ringed seals, the greatest impacts from diminished ice cover will be mediated through diminished snow accumulation. While winter precipitation is forecasted to increase in a warming Arctic, the annual formation of ice cover will be substantially delayed and the net effect will be lower snow accumulation on the ice. Ringed seals excavate subnivean lairs (snow caves) in drifts over their breathing holes in the ice, in which they whelp and nurse their pups during late winter and spring. Climate models used by the BRT projected that snow cover will be inadequate for the formation and occupation of birth lairs over substantial portions of the ringed seal's range within this century. Without the protection of the lairs, ringed seals—especially newborns—are vulnerable to freezing and predation. These threats are expected to lead to decreased survival, substantial population declines, and contractions of range for all of the ringed seal subspecies in the foreseeable future.

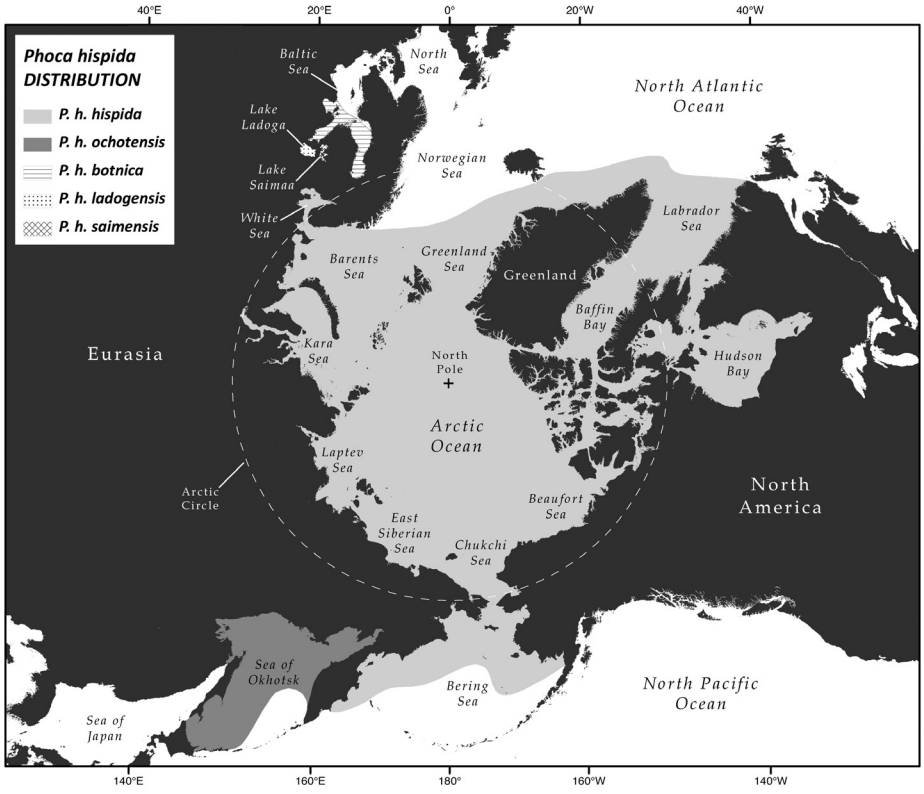


Figure 8. Distributions of the five subspecies of ringed seals.

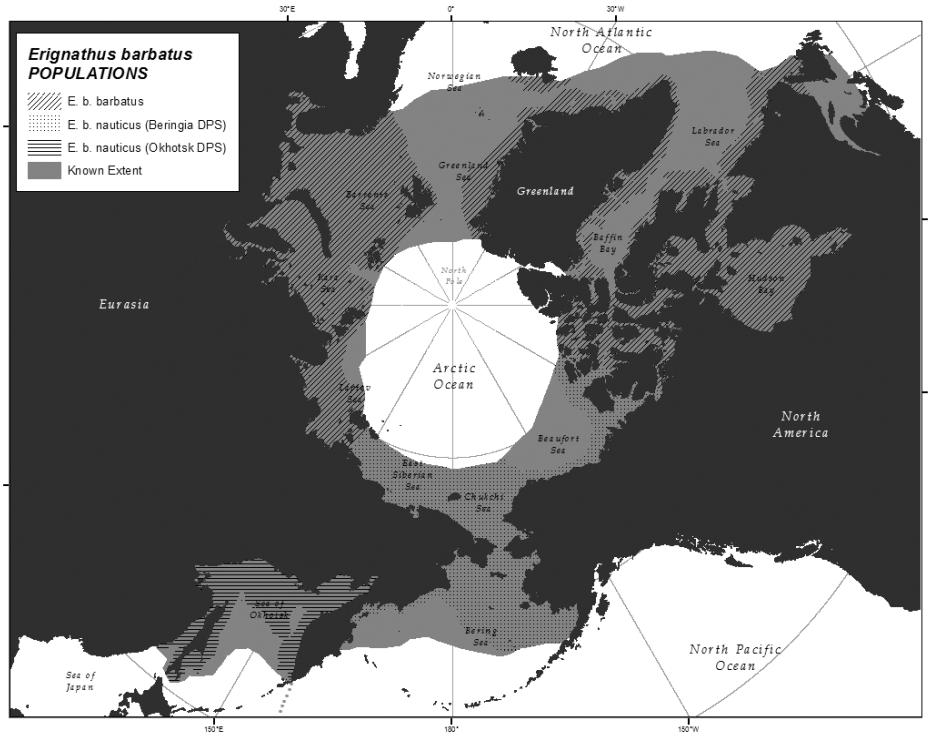


Figure 9. Distributions of the three population units of bearded seals.

As ringed and bearded seal populations decline, the significance of currently lower-level threats—such as ocean acidification and its associated impacts on prey communities; increases in petroleum development, commercial fisheries interactions, and shipping; and changes in populations of predators, competitors, diseases, and parasites—is expected to increase. Finally, because changes in their habitats are projected to be rapid relative to their generation time, and because females of both species produce only a single pup each year, the ability of ringed and bearded seals to adapt to these environmental changes will be limited.

Based on consideration of information presented in the status reviews, the BRT's risk assessments, and efforts being made to protect these species, NMFS issued proposed rules to list the Arctic, Okhotsk, Baltic, and Ladoga subspecies of ringed seals and the Beringia and Okhotsk DPSs of bearded seals as threatened species under the ESA on 10 December 2010. The Saimaa subspecies of ringed seal, which has a population of less than 300, was listed as endangered under the ESA in 1993 and no change in its listing status was proposed at this time. NMFS also determined that listing *E. b. barbatus* as threatened or endangered under the ESA was not warranted at this time. NMFS will consider comments and information from peer reviewers and the public regarding the proposed listings, and final listing determinations will be made by December 2011.

Links to the status review reports and proposed rules can be found on NMFS' Alaska Region website at www.alaskafisheries.noaa.gov/protectedresources/seals/ice.htm.

By Shawn Dahle and Michael Cameron

Resource Assessment & Conservation Engineering (RACE) Division

MIDWATER ASSESSMENT & CONSERVATION ENGINEERING (MACE) PROGRAM

Gulf of Alaska, Integrated Ecosystem Research Program (GOA IERP)

Scientists from the AFSC's Midwater Assessment & Conservation Engineering (MACE) Program and Resource Ecology and Fisheries Management (REFM) Division participated in two pilot studies for the Middle Trophic Level (MLT) (or forage fish) component of the Gulf of Alaska Integrated Ecosystem Research Project (GOA IERP), funded by NOAA and the North Pacific Research Board. The first pilot study occurred aboard the chartered fishing vessel *Sea View*, a 54-foot longliner, during 14-25 July in the eastern Gulf of Alaska (Fig. 1). The second study occurred

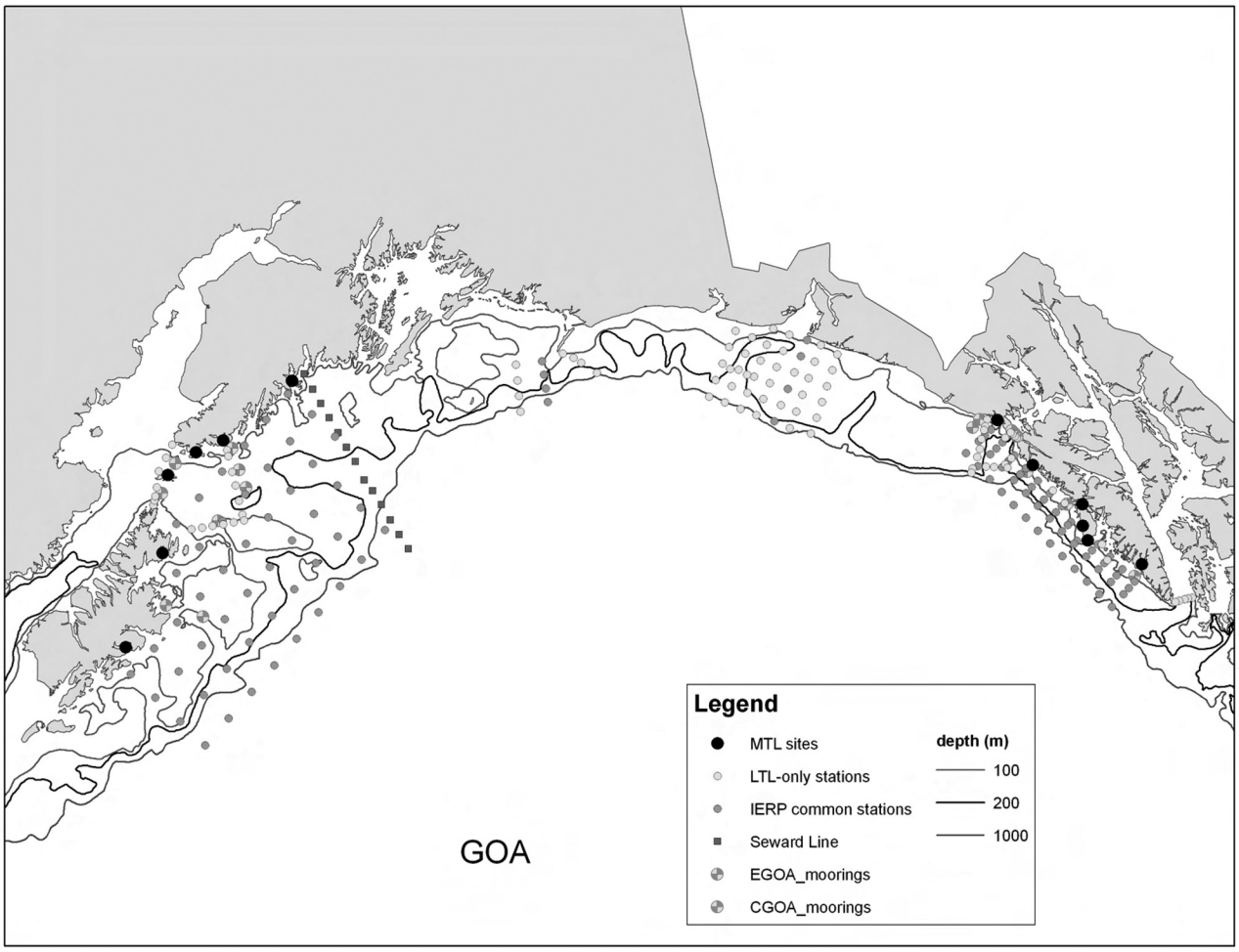


Figure 1. Map showing the Gulf of Alaska Integrated Ecosystem Research Project (GOA IERP) study area, Middle Trophic Level sites, and other GOA IERP-related station locations including the those for the spring cruise aboard the R/V *Thomas G. Thompson.*

aboard the chartered fishing vessel *Gold Rush*, a 99-foot trawler, from 23 October to 2 November in the central GOA.

The work focused mostly on small forage fish such as capelin (*Mallotus villosus*) and Pacific sand lance (*Ammodytes hexapterus*) as well as on juvenile stages of walleye pollock (*Theragra chalcogramma*) and Pacific cod (*Gadus macrocephalus*). The aspect of the MTL work presented here focused on the shallow (<40 m) near-shore habitat range of these fishes where use of specialized gear is needed to effectively sample these shallow depths and small fish sizes. In addition to verifying the suitability of proposed sampling sites (Fig. 1) such as accessibility to vessel, the objective of the two pilot studies was to evaluate whether a variety of fishing gears, including a beach seine, a purse seine, a variable-mesh vertical gill net, a midwater trawl, and a beam trawl were appropriate samplers for these species in their nearshore habitat. In addition, a conventional fine-mesh try net (i.e. a miniature bottom trawl) was modified into a small single-warp midwater net by the Research Fishing Gear Program staff and Research Nets, Inc. (Bothell, Washington) to evaluate during the second pilot study.

Acoustic measurements of fish abundance were made using three calibrated acoustic systems: 1) a Simrad ER60 echosounder and towed fin with 38- and 120-kHz transducers was deployed from the *Sea View*, 2) the vessel-mounted Simrad ES70 38-kHz system was used aboard the *Gold Rush*, and 3) a portable ER60 system with a pole-mounted 120-kHz transducer was deployed from a work skiff. A lowered video camera also was used to assess aquatic vegetation and identify fish species, and a conductivity-temperature-depth instrument was used to take vertical profile measurements to define hydrographic structures such as fronts relevant to the distribution of the near-shore fishes.

These pilot studies provided critical information during the early stages of the GOA IERP project to develop a comprehensive survey plan appropriate for the near-shore areas using a variety of sampling tools and methods. An important result of this field work was that the new midwater try-net could be effectively deployed using a single warp, which is important as future work will be conducted on smaller vessels that likely do not have the capability to fish double warp trawls. Also, large concentrations of young-of-year capelin (~5 cm standard length) were detected and successfully captured with the different sampling devices in the vicinity of the Barren Islands. Results of these two feasibility studies have provided valuable insight for planning the subsequent GOA IERP near-shore MLT field work is scheduled for April, July, and September in 2011 and 2012.

By Chris Wilson

RECRUITMENT PROCESSES PROGRAM

Gulf of Alaska, Integrated Ecosystem Research Program (GOA IERP)

The Recruitment Processes Program, as part of its Fisheries Oceanography Coordinated Investigations (FOCI) and North Pacific Climate Regimes and Ecosystem Productivity projects, began preparations for the 2011 spring field season. One of the major efforts is participation in the NPRB and NOAA sponsored Gulf of Alaska Integrated Ecosystem Research Program (GOA IERP). Our research group, with specific expertise in fish early life history and lower trophic level research, is a partnering with NOAA's Pacific Marine Environmental Laboratory, the University of Alaska Fairbanks, and Western Washington University to describe physical forcing and lower trophic level processes that affect the survival and recruitment of five fish species – walleye pollock, Pacific cod, sablefish, arrowtooth flounder, and Pacific ocean perch. Our first research cruise will occur in April on the research vessel *Thomas G. Thompson* concentrating on processes and mechanisms in the southeastern portion of the Gulf of Alaska. The cruise will collect ichthyoplankton samples in three major areas (Fig. 1): southeast Alaska , Yakutat Bay, and between Kodiak Island and Resurrection Bay. Members of the Recruitment Processes Program are also contributing expertise to GOA IERP in the analysis of existing data on fish larvae and physical forcing. We also are helping to construct new biophysical, numerical models that will test hypotheses about what mechanisms determine the advection of fish larvae to favorable nursery areas.

Climate and Ecosystems

The Program partners with the Pacific Marine Environmental Laboratory to conduct the North Pacific Climate Regimes and Ecosystem Productivity project. This project successfully submitted a proposal to Adaptations 2011 to present a case history on how climate and environmental data are used in marine resource management decisions in Alaska. The conference, to be held in the Washington D.C. area, features case histories of how resource management decisions in the United States are incorporating information about climate fluctuations and climate change into their decisions. The Alaska fisheries case history is currently the only marine example scheduled for the conference.

Ichthyoplankton Identification

The Recruitment Processes Program successfully determined the identity of an unknown fish larva that had been captured at low concentrations in numerous tows along the continental shelf break in the eastern Bering Sea and Gulf of Alaska. The identity of this small, (4-7 mm) dark black fish larva had eluded biologists for many years. Recently the Program applied molecular genetics techniques (DNA barcoding), to determine that these specimens were the larvae of the flabby sculpin (*Zesticelus profundorum*) (Fig. 2). Program scientists have completed a formal description of the larva's morphological characteristics so that other scientists and students will be able to identify it in their own plankton tows.

By Jeffrey Napp

GROUNDFISH ASSESSMENT PROGRAM

Fossil Fish Named After AFSC Scientist Jay Orr

Dr. James W. Orr, an ichthyologist at NOAA's Alaska Fisheries Science Center in Seattle, was recently recognized for his contributions to ichthyology. A new genus of an extinct handfish was named in his honor: *Orrichthys* for the species *Orrichthys longimanus*. Species of the handfish family (Brachionichthyidae) are now found in waters off Australia and Tasmania, where with their long paired fins, they "walk" on the ocean bottom like tetrapods. The species was described and named by Drs. Giorgio Carnevale of the Universita' de Pisa and Ted Pietsch of the University of Washington in a recent issue of the Zoological Journal of the Linnean Society (Zool. J. Linnean Soc., 2010, 160:621–647).

By Mark Wilkins

SHELLFISH ASSESSMENT PROGRAM

The Effects of Holding Space on Juvenile Red King Crab (*Paralithodes camtschaticus*) Growth and Survival

Alaskan red king crab (*Paralithodes camtschaticus*) historically supported one of the most valuable crab fisheries in the United States; however, populations declined in the early 1980s and have not recovered despite closures of some areas to commercial fishing. The population decline and continued low population levels in the Gulf of Alaska have spurred early life-history research in order to better understand recruitment processes, habitat requirements, predator/prey interactions, effects of environmental change, and the feasibil-

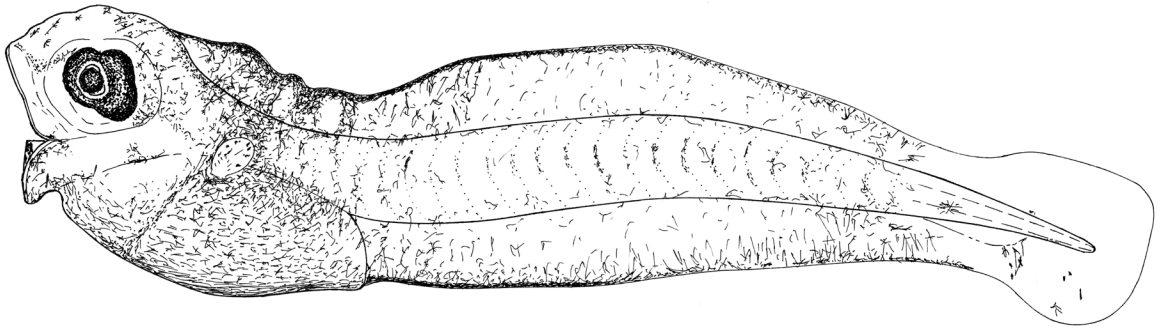
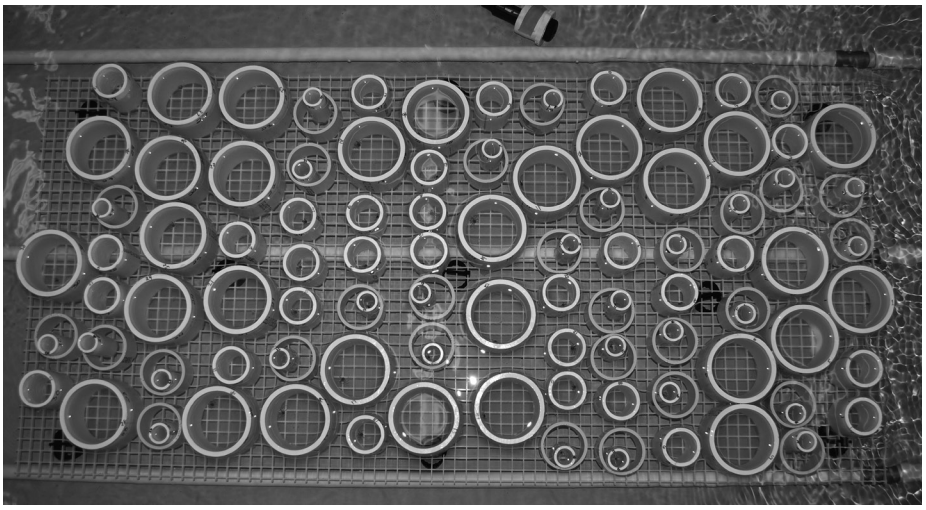


Figure 2. Larva of the flabby sculpin (*Zesticelus profundorum*).



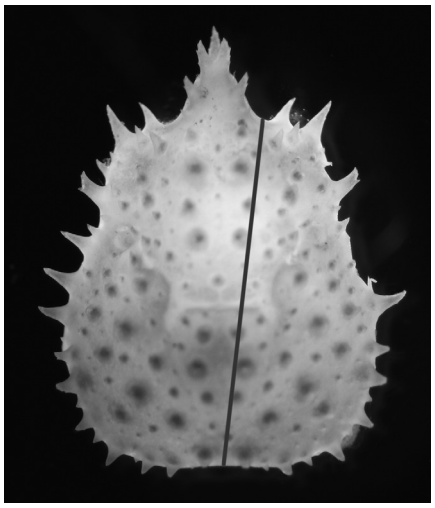


Figure 3 (left): The experimental rearing tank consists of three treatment holding cells, 20, 40, and 77 mm diameter and 30 replicates per treatment. At the beginning of the experiment, one juvenile red king crab was randomly placed in each holding cell. Figure 4 (right). Red king crab carapace removed from the molt. The dark line illustrates how carapace length is measured.

ity of rehabilitating the population via stock enhancement.

The advancement of research and stock enhancement necessitates the development of reliable techniques for producing adequate numbers of juvenile king crab in captivity. When crustaceans, including juvenile red king crab, are reared communally, high rates of mortality due to cannibalism result in low yields. One potential strategy to reduce loss from cannibalism is to rear crustaceans in individual cells. Small holding cell size, however, can result in decreased growth or increased mortality. Therefore it is essential to identify the optimal holding cell size, both for mass culturing efforts and for experimental design purposes.

To determine if space limitation affects juvenile red king crab growth and survival, we reared red king crab (3.67- 8.30 mm carapace length), in 20-, 40-, and 77-mm diameter holding cells (Fig. 3) for 274 days. Holding cells were checked daily for mortalities and molts which were recorded and removed. To examine growth, carapaces were carefully removed from all molts and mortalities and photographed under a dissecting scope. Carapace length was measured using image analysis software (Fig. 4). At the termination of the experiment, all surviving crab were sacrificed and measured.

Crab size did not differ among holding cell sizes after the first, second or third molts; however at the end of the experiment, crabs reared in small holding cells were significantly smaller (17%) than those reared in the large holding cells (Fig. 5). Carapace length did not differ between crabs reared in small and medium holding cells or medium and large holding cells.

The inter-molt period in days did not differ among crab reared in different sized holding cells between the beginning of the experiment and the first molt or between the first and second molt (Fig. 5). The inter-molt period was not compared between the second and third molt as only 84% of crabs reared in large holding cells and 40% of the crabs in the small and medium holding cells underwent a third molt by the termination of the experiment; however, these data suggest that the inter-molt period is shorter for juveniles reared in large holding cells, as a higher percentage of these crabs underwent a third molt compared to those reared in small and medium holding cells.

Overall survival at the end of the experiment was 83% in the large and medium holding cells and 17% in the small holding cells (Fig. 6). This corresponds to mortality rates in the small holding cells being an order of magnitude larger than those in the medium and large holding cells.

Small holding cell size reduced both growth and survival of juvenile red king crab. For rearing individual juvenile crab, the optimal holding cell size is as small as possible without substantially reducing growth and survival. Based upon these criteria and the cell sizes examined in this study, the medium holding cell is ideal to rear juvenile red king crabs of the sizes examined; mortality rates were no higher than those in the large holding cells while growth rates were, only minimally lower. Our results provide laboratories and hatcheries the information to determine if achieving increased survival outweighs the increased labor and space requirements associated with rearing juveniles individually and to determine the appropriate size of container to use in experiments.

By Katherine Swiney and Christopher Long

Canada-United States Bitter Crab Disease Project

Frank Morado of the AFSC's Fisheries Resources Pathobiology team traveled to Charlottetown, Prince Edward Island, Canada, on 31 October to discuss current status and progress of a 3-year project on bitter crab disease in snow crabs which is funded by the Natural Sciences and Engineering Research Council of Canada. Members of the research team include staff scientists from the Department of Fisheries and Oceans Canada (Newfoundland, Nova Scotia, New Brunswick, and Quebec provinces), University of Alaska Southeast, University of Maryland Eastern Shore, University of Prince Edward Island and the AFSC. The meeting provided an opportunity for training of University of Prince Edward Island collaborators on tools and techniques in the study of the causative agent of the disease, a parasitic dinoflagellate of the genus *Hematodinium*. The meet-

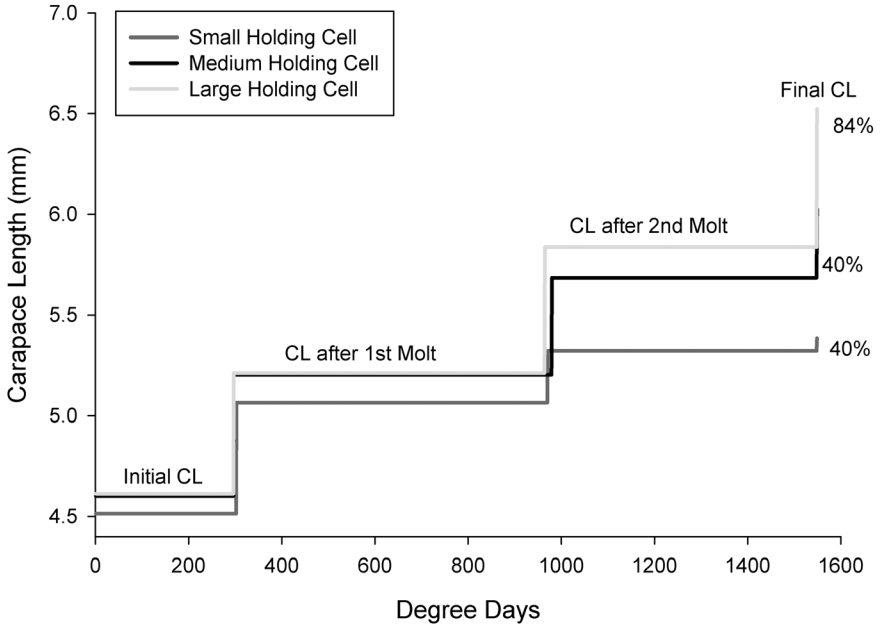


Figure 5. Mean carapace lengths after each molt and at the end of the experiment and mean inter-molt period in degree days for crabs reared in small, medium, and large holding cells. Reported percentages are the percent of crabs alive at the end of the experiment in each holding cell size that underwent a third molt.

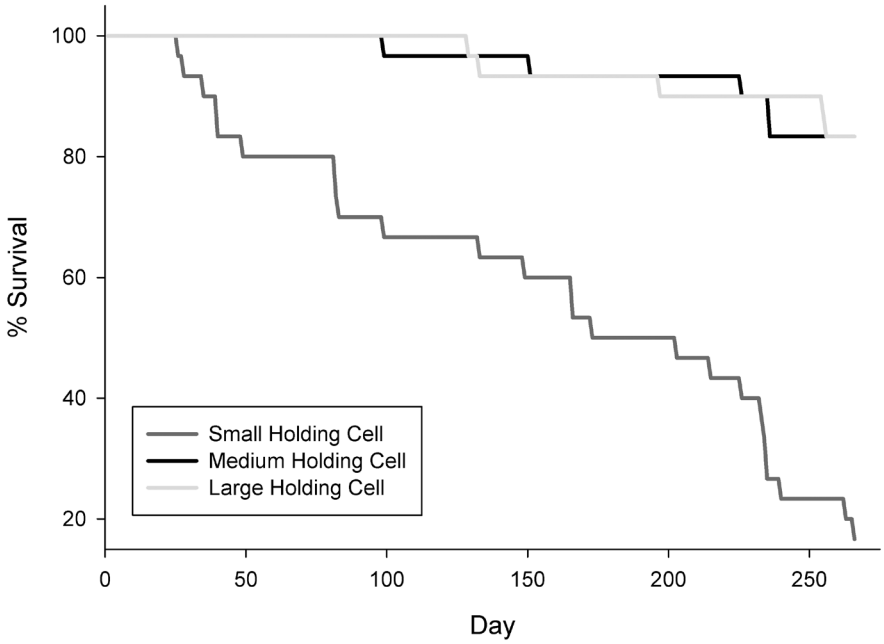


Figure 6. Percent survival by experimental day of juvenile red king crab reared in small, medium, and large holding cells. We modeled survival with the following equation $S = e^{-mT}$, where S is proportional survival, m is the mortality rate and T is the time in days. Mortality rates estimated by maximum likelihood are 0.0039 (SE = 0.000068) for small holding cells, and 0.00037 (SE = 0.000013) for the medium and large holding cells.

ing also provided an opportunity to plan future experiments identified within the funded proposal. In addition, Frank met with graduate students with the project and participated in their graduate school committee meetings. The trip was successful as problem areas of the project were identified and solutions were presented.

By Frank Morado

Gulf of Alaska Small-Mesh Trawl Survey

The annual small-mesh trawl survey for shrimp and forage fish was conducted jointly by scientists from the RACE Division and the Alaska Department of Fish and Game (ADF&G) in October 2010. The ADF&G research vessel *Resolution* conducted 160 tows around Kodiak Island, Shelikof Strait, and along the Alaska Peninsula (Fig. 7). This recent survey was the latest effort in a collaboration that dates back to 1972.

The length of the small-mesh time series makes it one of the premier datasets in the North Pacific. It was instrumental, for example, in documenting the major Gulf of Alaska marine regime shift of 1976-77. Recently it has been combined with datasets from around the world for retrospective fishery analyses on a global scale including articles in the journals *Science,* "Rebuilding Global Fisheries" by Boris Worm et al. and *Nature*, "The trophic fingerprint of marine fishes" by Trevor Branch et al.

The Gulf of Alaska marine ecosystem changes documented in the 1976/77 regime shift are perhaps best illustrated by survey catches in Pavlof Bay, on the south side of the Alaska Peninsula. This bay has been the most consistently sampled in the survey area and still exhibits effects of the reorganization which resulted in the decline of shrimp and capelin (*Mallotus villosus*) and the rise of flatfish and Pacific cod (*Gadus macrocephalus*) (Fig. 8). The 2010 survey saw little change in species composition from previous years although shrimp catches have recently increased modestly to around 3 kg/km. The long-term response across the Gulf of Alaska to the 1976/77 shift, however, has not been uniform. Marmot Bay on the northeast corner of Kodiak Island also saw community reorganization during the regime shift but shrimp populations, after a period of decline, stabilized at relatively high levels of approximately 25 kg/km (Fig. 8).

An interesting finding from the 2010 survey was the collapse of northern shrimp (*Pandalus eous*) in Wide Bay. Catch rates declined from 50 kg/km in 2009 to only 1.5 kg/km in 2010. The cause of this decline is not known, but the 2009 catch of 125 plain sculpin (*Myoxocephalus jaok*) per kilometer suggests that predation may have played a role in the decline. Examination of plain sculpin stomachs during the 2010 survey revealed numerous northern shrimp, even at the current low shrimp densities. Also

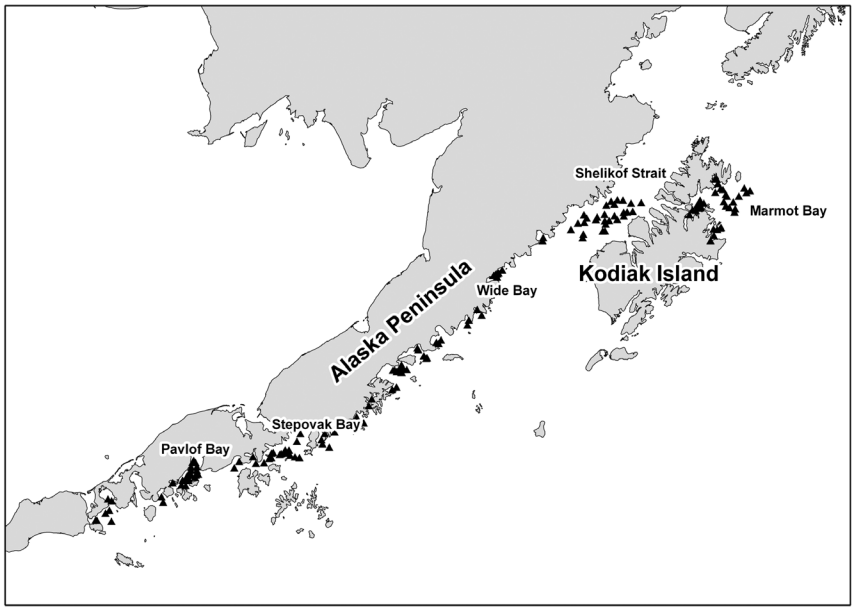


Figure 7. Haul locations (triangles) in the central and western Gulf of the 2010 small-mesh trawl survey.

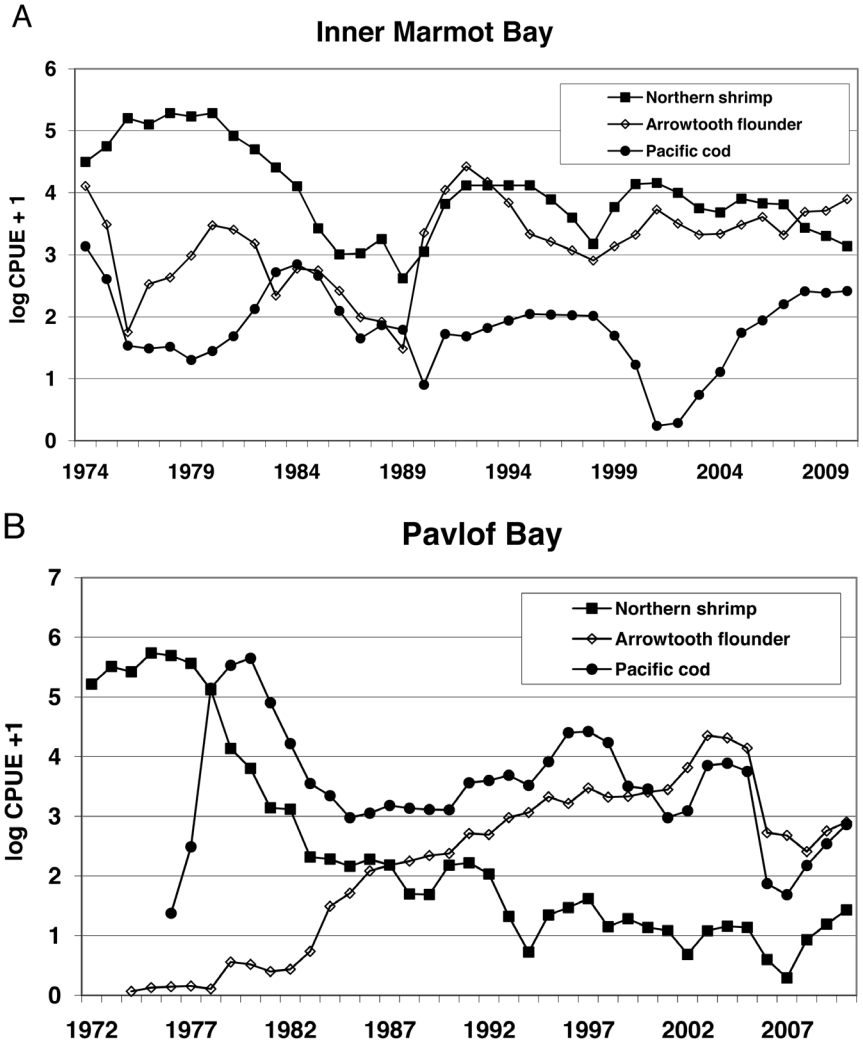


Figure 8. Catch trends (3-year running average) of arrowtooth flounder, Pacific cod, and northern shrimp from Inner Marmot (A) and Pavlof Bays (B) from the 2010 small-mesh survey.

of interest is the near record level of eulachon *Thaleichthys pacificus* catches with the highest catches of 160 kg/km found in Stepovak Bay. Other areas with high densities of eulachon were Marmot Bay and Shelikof Strait.

Efforts continue to refine and integrate the databases that make up the time series of small-mesh surveys in the Gulf of Alaska from RACE Division and multiple ADF&G offices. Metadata has been developed, data proofing and editing methods have been implemented, and a method for versioning has been identified so that this dataset can continue to be updated while being made available to the public. Future efforts will continue to incorporate historical archived datasets into the database and to ultimately provide a tool for researchers to access the metadata and existing publications associated with this time series.

By Dan Urban

Resource Ecology & Fisheries Management (REFM) Division

RESOURCE ECOLOGY & ECOSYSTEM MODELING PROGRAM

DNA-based Identification of Stomach Contents

Fast identification of prey species using morphological characteristics is not always possible because some common prey species found in stomach contents disarticulate at the head and tail fairly rapidly, and the remains consist of an incomplete vertebral column with some flesh attached. In collaboration with Melanie Paquin and Mike Canino (RACE Divison) we are developing rapid and cost-effective methods of molecular identification to apply to groups of difficult-to-distinguish species. The polymerase chain reaction (PCR) method and restriction fragment length polymorphisms (RFLP) were used to develop protocols for the identification of forage fish prey found in fish stomachs. Taxonomic identifications of the forage fish prey were made to species using the physical characteristics of the fish remains. Tissue samples from each of the forage fish prey were collected for molecular analysis using the PCR-RFLP protocols. We found 100% concordance in species identifications using the PCR-RFLP protocol and identifications using remaining physical characteristics. In addition, six taxonomically unidentifiable fish prey were sequenced, providing identification of a Pacific sand lance (*Ammodytes hexapterus*), a northern

smoothtongue (*Leuroglossus schmidti*), a northern rock sole (*Lepidopsetta polyxystra*), and three sculpins (family Cottidae).

By Troy Buckley and Richard Hibpshman

Fish Stomach Collection and Lab Analysis

During the fourth quarter of 2010 Resource Ecology and Ecosystem Modeling (REEM) Program staff focused primarily on the analysis of fish stomachs from the Bering Sea. The contents of 4,106 stomach samples from 15 species were analyzed from the Bering Sea, and 189 walleye pollock stomach samples from the Gulf of Alaska were analyzed. Detailed analysis with high taxonomic resolution of prey has begun on small-mouthed flatfish for an essential fish habitat (EFH) project and on walleye pollock for the Bering Sea Integrated Ecosystem Research Program (BSIERP) project. Both of these projects incorporate independent information on the available prey community. Laboratory personnel also dried 474 tissue samples in preparation for stable isotope analysis. Fisheries observers returned stomach samples from 462 walleye pollock and 1 arrowtooth flounder from the eastern Bering Sea, and 149 walleye pollock from the Gulf of Alaska. In total, 15,905 records were added to the REEM food habits database.

By Troy Buckley and Geoff Lang

Preliminary Results of the 2009 EBS Flatfish Essential Fish Habitat Study

A total of 1,147 Alaska plaice (*Pleuronectes quadrituberculatus)*, northern rock sole (*Lepidopsetta polyxystra)*, flathead sole (*Hippoglossoides elassodon)*, yellowfin sole (*Pleuronectes asper)*, and longhead dab (*Pleuronectes proboscideus)* stomachs were collected from 27 stations in the eastern Bering Sea. These stomachs were analyzed as part of an EFH project (in collaboration with Cynthia Yeung, RACE Division) that focuses on correlating the diets of some small-mouth flatfish with their specific habitats in the eastern Bering Sea. Grab samples were collected at each of the 27 stations. The habitat types for the stations were categorized as sandy (% sand ≥ 80), muddy sand (50 ≤ % sand < 80), sandy mud (50 ≤ % mud < 80), and muddy (% mud ≥ 80).

The diets of these small-mouth flatfish included polychaetes, clams, amphipods (Fig. 1), and brittle stars. Diets varied among predator species, among size-groups of the same predator, and among habitat types. An interesting finding was that the diet shifted from habitat to habitat, even for the same predator species. The results indicate that it is important to combine habitat information with food habits information for better understanding of the predator-prey relationships in the marine ecosystem.

By Mei-Sun Yang

Figure 1. Stegocephalidae amphipod from the eastern Bering Sea. Photo by Caroline Robinson.

Trophic Level Patterns Indicated by Stomach Contents and Stable Istotope Analyses

Dr. Kerim Aydin attended the annual meeting of the North Pacific Marine Science Organization (PICES) held in Portland, Oregon, from 22 to 31 October. He presented a paper entitled "An analysis of 30 years of seasonal and geographic variability in marine food webs through fish food habits and stable isotope analyses." The paper summarized the final results of a North Pacific Research Board funded project. Of particular interest was an indication that trophic levels as calculated from stomach contents showed higher trophic levels for walleye pollock on the outer shelf of the eastern Bering Sea than the inner shelf, while analysis of stable isotope ratios of nitrogen showed higher trophic levels on the inner shelf, particularly in Bristol Bay. This difference highlights that stomach contents analysis primarily measures trophic level as a function of zooplanktivory/piscivory within fish, while stable isotope results may be dominated by lower-trophic level (within zooplankton) processes such as uptake water mass and microzooplankton food-chain length.

By Kerim Aydin

Seabird Investigations

The AFSC's Coordinated Seabird Studies Group serves a broad suite of end-users and is highly collaborative, relying on many in and outside the AFSC to produce products that interest the group's end-users. The group relies on the AFSC's Fisheries Management and Analysis (FMA) Division to produce high-quality data through fisheries observers deployed to commercial fishing vessels in the Alaskan groundfish fisheries. In the past, the Coordinated Seabrid Studies Group has worked closely with the Washington Sea Grant Program on seabird mitigation, which now includes the Coastal Observation and Seabird Survey Team (COASST) Program, which provides the seabird component for observer training. Several other contractors are key to the success the program has achieved. The Group's current products focus primarily on seabird interactions with commercial fisheries, including basic data on seabird bycatch; a wide array of other information and data from the field, including the collec-

tion of seabird carcasses for life history and food habits research; improving methods for monitoring seabird bycatch; monitoring the effectiveness of seabird mitigation measures; supporting or conducting research into bycatch mitigation measures; completing annual reports of seabird bycatch estimates in Alaskan groundfish fisheries; and making all this information available through conference presentations and posters, AFSC Quarterly and Processed Reports and Technical Memoranda, white papers, and journal articles.

One of our top priorities is to develop systems and processes for producing annual reports of seabird bycatch estimates for the Alaska Groundfish Fisheries. We are currently collaborating closely with the Sustainable Fisheries Division in the NMFS Alaska Regional Office to provide some automation of that previously staff-intense process by using the Catch Accounting System. Although much of our core work currently involves seabird/fishery interactions and serving the needs of clients such as the U.S. Fish and Wildlife Service, we are also working with the National Seabird Program and other science centers to make apparent the great value of using seabirds as a tool for studies on marine ecosystems and processes. As the core fishery interaction work is developed and stabilized with appropriate funding, we hope to report on this much broader aspect of NOAA's involvement with seabirds in Alaskan waters.

By Shannon Fitzgerald

Outreach in the Pribilof Islands

The Bering Sea Integrated Ecosystem Research Program (BSIERP) is a partnership between the North Pacific Research Board and the National Science Foundation, funding 35 linked research projects related to the Bering Sea ecosystem. As part of BSIERP, Dr. Ivonne Ortiz travelled to St. Paul, Pribilof Islands 11-13 November 2010 to give a class to K-12 students about the connections between climate, oceanography, plankton, fish, economics, and management. The class included a talk based on the vertical model developed as part of the ecosystem modeling portion of BSIERP and a computer lab section with exercises based on Alaskan food webs and fish diets.

By Ivonne Ortiz

Lowell Wakefield 2010 Symposium

The 26th Lowell Wakefield Fisheries Symposium was held in Anchorage, Alaska, 8-11 November 2010. The symposium series is sponsored by Alaska Sea Grant and has brought together scientists, managers, fishers, and other interested stakeholders to discuss fisheries topics since 1982. This year's topic was "Ecosystems 2010: Global Progress on Ecosystem-based Fisheries Management." The meeting was well attended with 108 participants from 19 nations. A full description of the meeting with the program and abstracts is available at http://seagrant.uaf.edu/conferences/2010/wakefield-ecosystems/index.php.

Drs. Ivonne Ortiz and Sarah Gaichas gave four presentations on behalf of the REEM Program. Presentations included "From the Aleutians to the Arctic: Integrating Ecosystem Approaches within the Alaska Fishery Management Process" by Stephani Zador, "The FEAST model for the Bering Sea: Forage/Euphasiid Abundance in Space and Time" by Kerim Aydin, "Use of Regional Food Webs to Explore Fisheries and Foragers Interactions during Cold and Warm Years: A Case Study on Northern Fur Seals" by Ivonne Ortiz, and "What Drives Dynamics in the Gulf of Alaska? Integrating Hypotheses of Species, Fishing, and Climate Relationships Using Ecosystem Modeling" by Sarah Gaichas. Sarah Gaichas also presented work completed in collaboration with Michael Fogarty and other colleagues at the NMFS Northeast Fisheries Science Center, the Canadian Department of Fisheries and Oceans, and the University of Washington. The presentation was titled "Assembly Rules for Aggregate-Species Production Models: Simulations in Support of Management Strategy Evaluation."

By Sarah Gaichas and Ivonne Ortiz

Ecosystem Considerations for 2011

REEM staff completed the Ecosystem Considerations appendix to the stock assessment and fisheries evaluation (SAFE) report to the North Pacific Fishery Management Council (NPFMC). This year, the Ecosystem Considerations appendix includes both new and updated sections. The section describing ecosystem and management indicators includes updates to 41 individual contributions and presents 4 new contributions. These include 1) Late Summer/Fall Abundances of Large Zooplankton in the Eastern Bering Sea, 2) Fall Condition of YOY Predicts Recruitment of Age-1 Walleye Pollock, 3) Juvenile Salmon Growth and Temperature Change as Predictors of Subsequent Recruitment of Groundfish in the Gulf of Alaska and the Bering Sea, and 4) Pribilof Islands Seabird Trends.

The ecosystem assessment section includes a new synthetic eastern Bering Sea (EBS) ecosystem assessment which was developed by a multidisciplinary team of experts during a series of workshops in September and October 2010. For more details about this assessment and the associated *Report Card* see the summary by Gaichas and Zador in this quarterly report. New this year, the ecosystem assessment also includes a *Hot Topics* subsection which was designed to present a succinct overview of potential concerns for fishery management, including endangered species issues and early warnings of potential future fishery management interest. Endangered species information critical to fishery management presented this year include updates on short-tailed albatross bycatch and Steller sea lions in the eastern Bering Sea. Early warnings of potential future fishery management interest this year includes a summary of rare species observed in recent years in the eastern Bering Sea.

Findings from the Ecosystem Considerations appendix were presented to the NPFMC joint plan teams in September and November and to the NPFMC's Science and Statistical Committee in December. To see the appendix in its entirety see the AFSC website at access.afsc.noaa.gov/reem/ecoweb.

By Stephani Zador

New Eastern Bering Sea Ecosystem Assessment and Report Card

This year for the first time, the Ecosystem Considerations appendix to the stock assessment and fishery evaluation (SAFE) report presented to the North Pacific Fishery Management Council (NPFMC) contains a "Report Card" on the status and trends of 10 comprehensive ecosystem indicators for the eastern Bering Sea. The EBS Report Card provides a 2-page summary of the new synthetic Eastern Bering Sea Ecosystem Assessment, which was developed by a multidisciplinary team of experts during a series of workshops in September

and October 2010. All of this work was completed with the support of the Fisheries and the Environment (FATE) Program, as well as the North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) Program.

The Eastern Bering Sea Ecosystem Synthesis Team included Sarah Gaichas, Kerim Aydin, Troy Buckley, and Stephani Zador (AFSC REEM Program), Nick Bond (University of Washington), Phyllis Stabeno and Lisa Guy (Pacific Marine Environmental Laboratory), Jeff Napp, Patrick Ressler and Jerry Hoff (AFSC RACE Division), Anne Hollowed, Martin Dorn, Jim Ianelli, and Tom Wilderbuer and Pat Livingston (AFSC REFM Division), Franz Mueter (University of Alaska), Robert Foy (AFSC Kodiak Labortory), Ed Farley of (AFSC Auke Bay Laboratories), Lowell Fritz (AFSC National Marine Mammal Laboratory), Sue Moore (University of Washington, Applied Physics Laboratory), and Diana Evans (NPFMC).

The team first met in September 2010 to develop a list of synthetic ecosystem indicators for the eastern Bering Sea. The suite of indicators was selected to represent key ecosystem components by choosing the best available indicators related to 1) atmosphere and upper-ocean physics, 2) lower trophic levels and primary production, 3) fish and shellfsh distribution and abundance, 4) fish and shellfsh production, 5) fisheries productivity, 6) seabirds, 7) pinnipeds, and 8) whales. During the October 2010 workshop, the team developed the new eastern Bering Sea Report Card. For this initial EBS Ecosystem Assessment, the team focused on a subset of 10 broad, community-level indicators to determine the current state and likely future trends of ecosystem productivity overall, including switches between major pathways (benthic/pelagic). The team also selected indicators thought to best guide managers on ensuring the needs of non-fishery apex predators and maintaining a sustainable species mix in the harvest, given the current state and likely future trends of overall productivity and the distribution/strength of pathways.

The EBS Report Card and Ecosystem Assessment were presented to the NPFMC Groundfish Plan Teams in November 2010, and to the NPFMC in December 2010 as part of the annual catch specification process. The final report, including the Report Card and the Ecosystem Assessment, is available on the AFSC website at http://access.afsc.noaa.gov/reem/ecoweb/Eco2010.pdf.

By Sarah Gaichas and Stephani Zador

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Bioeconomic Model for Estimating Maximum Economic Yield of North Pacific Crab Stocks

Two sets of linked biological and economic models were developed for the snow crab (*Chionoecetes opilio*) resource in the eastern Bering Sea (EBS snow crab). The first bioeconomic model is based on the population dynamics model on which the 2009 stock assessment was based. This population dynamics model accounts for sex, maturity state, shell condition and length, and is fitted to a variety of data sources including survey indices of male and female abundance and the length-compositions of survey and fishery catch and bycatch. The economic component of this bioeconomic model relates fishing mortality in the directed pot fishery to sea days and estimates variable costs related to fuel, food, and bait (the latter by relating sea days to pot lifts). The second bioeconomic model is based on a simpler population dynamics model (males only with fewer size-classes) and the same economic model. This simplified model fits the available data as well as the more complicated model and is such that it could be used in dynamic optimization analyses. The two bioeconomic models are compared for the case in which the population dynamics are deterministic (no process error about the Beverton-Holt stock-recruitment relationship). The estimates of maximum sustainable yield (MSY) and maximum economic yield (MEY), and the corresponding effort levels, E_{MSY} and E_{MEY}, are MSY: 44,100 t vs. 44,900 t; MEY: 156.9 million $ vs. 162.0 million $; E_{MSY}: 4.745 vs. 7.140 sea days; and E_{MEY}: 4,165 vs. 6,309 sea days. The version of MEY used here is a static concept and does not account for the impact of the initial state of the resource as well as costs and revenues during transient periods. These factors are important for EBS snow crab because this stock was assessed to be below the biomass corresponding to MSY in 2009. The effort level which maximizes net present value (discount rate = 0.05) is 5,570 sea days (i.e., higher than E_{MSY}). Sensitivity tests explored the impact of changes to major assumptions of the models, including the value assumed for natural mortality, *M*, the form of the stock-recruitment relationship (Beverton-Holt or Ricker), and whether account is taken of parameter uncertainty and recruitment fluctuations.

By Mike Dalton and Brian Garber-Yonts

Involving Communities to Better Understand the Role of North Pacific Fisheries

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 North Pacific Fishery Management Council (NPFMC), the AFSC, and community stakeholder organizations have identified ongoing collection of community-level socio-economic information that is specifically related to commercial fisheries as a priority.

To address this need, the AFSC's Economic and Social Sciences Research (ESSR) Program has been preparing the implementation of the Alaska Community Survey, an annual voluntary data collection program initially focused on Alaska communities for feasibility reasons, in order to improve the socio-economic data available for consideration in North Pacific fisheries management. In partnership with community organizations and individuals from fishing communities around Alaska, ESSR staff have been working to ensure that detailed community level socio-economic and demographic data are collected at comparable levels of spatial and thematic resolution to those levels of commercial fisheries data collection. Such community-level data will facilitate analysis of the impacts of proposed changes in commercial fisheries management, both within and across North Pacific communities involved and engaged in commercial fishing. These data will also help scientists and NPFMC staff better understand 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.

Furthermore, the ESSR Program is beginning revision of the document "Community Profiles for North Pacific Fisheries—Alaska" and anticipates starting the profile revision process in summer 2011. In community meetings held by AFSC social scientists in August and September 2010, community input was sought on how the community profiles can better represent communities and their ties to North Pacific fisheries. Much of the input received at the meetings were suggestions for new types of socio-economic data to better represent the interests of communities in the fisheries management process and in socio-economic impact analyses. However, a large amount of the data requested by communities for inclusion is not obtainable from other sources and is therefore being requested directly from communities through the implementation of the Alaska Community Survey.

Types of data to be collected in the survey included recommendations from representatives at the community meetings and a subset of those identified by the NPFMC's Comprehensive Socioeconomic Data Collection Committee. Recommendations included 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.

The survey instrument was finalized in October 2010 after significant input from survey design experts and cognitive interviews. The survey will be sent to all communities included in the revised community profile document following a modified version of the Dillman Tailored Design Method. This method consists of multiple contacts, including an advance letter, telephone recruitment, initial mailing, follow-up postcard reminder, a follow-up telephone interview, and second full mailing. A census of the population will be necessary in order to obtain the same set of unique information about each community's involvement in fishing for use in revising the 2005 community profiles. Respondents are identified as the mayors, tribal leaders or heads of non-profit corporate entities for each community. Full survey implementation is expected to begin in early spring 2011.

By Amber Himes, Christina Package, and Jennifer Sepez

Quantitative Measures of Risk Applied to North Pacific Commercial Fisheries

As fisheries management shifts focus to dual socio-ecological success, quantitative risk measures provide a way to distill complex system dynamics into simple metrics that are meaningful for resource users and which can be used to track management performance, for example through management strategy evaluation. Borrowing from investment theory, we introduced several risk measures for application to fisheries, calculating semideviation and conditional value-at-risk catch and revenue risks for 90 commercial fisheries in Alaska (nearly a complete census). We estimated the relationship between fishery characteristics and catch risks using nonparametric random forests to highlight attributes associated with high or low risk.

Catch and revenue risks for individual Alaskan fisheries are substantial and are higher than farmed food alternatives. Revenue risks are greater than catch risks for most fisheries, indicating that price variability is an additional source of risk to fishermen. Results show that higher productivity species tend to be higher risk, and there is an increasing gradient of risk moving north and west across North Pacific waters, with the remote western Bering Sea fisheries tending to be highest risk. Low risk fisheries tend to be large catch and support larger fleets. Finally, fisheries with greater catch history under some form of dedicated access privileges tend to have lower catch risks.

By Mike Dalton

Bioeconomic Assessment of Ocean Acidification on Bristol Bay Red King Crab

Ocean acidification research by AFSC scientists is following the priorities established by a 5-year plan published in 2008 (on the web at http://www.afsc.noaa.gov/Publications/ProcRpt/PR2008-07.pdf). Commercially important calcareous species (shellfish) are first priority because of their economic value and because these species are likely to suffer direct effects of reduced $CaCO_3$ availability. The aim of this project is to develop an integrated bioeconomic model to make long-term (30-50 year) probabilistic projections for the Bristol Bay red king crab fishery under alternative management and environmental scenarios. A version of the full Bristol Bay red king crab stock assessment model was recoded for use in this project. In addition, a simpler (i.e., males-only, fewer size-classes) version is under development for use in the bioeconomic model. The environmental scenarios will involve exogenous forcing from ocean acidification on key life-history parameters (i.e., pre-recruit growth and mortality rates) that will be explicitly represented in the bioeconomic model. In particular, pre-recruit survival and growth will be represented in a life-stage based (i.e., Lefkovitch) model that is currently being developed. Changes in the pre-recruit model will be informed by results for a range of pH levels from experiments being conducted at the AFSC Kodiak Laboratory on growth and survival of larvae and juvenile red king crab.

By Mike Dalton and Dusanka Poljak

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

Groundfish Stock Assessments for 2011: Fishery Quota Recommendations

The preparation of the stock assessment and fishery evaluation (SAFE) reports (www.afsc.noaa.gov/refm/stocks/assessments.htm) (more than 3,000 pages) provides the scientific basis for groundfish catch recommendations. These reports present analysis of the extensive data collected by NMFS-trained fisheries observers and AFSC scientists aboard dedicated research surveys. Observer data are used to estimate catch of target and prohibited species (e.g., salmon, crab, herring, and Pacific halibut) to ensure that fisheries do not exceed annually specified total allowable catches (TACs) or violate other fishery restrictions (such as time-area closures). Results from the AFSC surveys combined with observer data are critical in conditioning statistical stock assessment models. Results from these models (and their estimates of uncertainty) are used to determine the status of individual species and make recommendations for future catch levels.

This TAC-setting process involves annual presentations of these reports at a series of public meetings.

The reports present analyses on individual stocks and/or species groups and provide targets and limits—acceptable biological catches (ABC) and overfishing levels (OFL), respectively. The North Pacific Fishery Management Council's (NPFMC, Council) Groundfish Plan Teams review drafts of these reports in September and November meetings and make recommendations for ABC and OFL levels (one each for the Bering Sea and Aleutian Islands and Gulf of Alaska regions) for review by the NPFMC Scientific and Statistical Committee (SSC). The SSC then makes the final ABC recommendation to the Council and the Council's Advisory Panel of industry representatives makes TAC recommendations during the December NPFMC meeting. Finally, the recommended TAC levels are adjusted (for some species) by the Council to ensure that other constraints (e.g., limiting the sum of all TACs in the Bering Sea and Aleutian Islands to be less than 2 million t) are met.

The following rule applies to all Federally managed groundfish stocks (or stock complex) in a given year:

$$\text{Catch} \leq \text{TAC} \leq \text{ABC} < \text{OFL}$$

In practice, catch is often less than TAC and TAC is often less than ABC. The multispecies management system is therefore based on the premise that individual components fished at safe sustainable levels results in overfishing being avoided.

The AFSC Midwater Assessment and Conservation Engineering (MACE) Program conducted two major surveys in 2010: the winter echo-integration trawl survey in Shelikof Strait and nearby areas and the entire shelf region of the eastern Bering Sea (EBS), extending into the Russian exclusive economic zone (EEZ). The AFSC's Marine Ecology and Stock Assessment Program scientists conducted the annual longline survey which is designed primarily for sablefish but also produces data used in Greenland turbot and some rockfish assessments. This survey covers the slope regions of the Gulf of Alaska (GOA) along with segments of the Bering Sea and Aleutian Islands regions. The Groundfish Assessment Program (RACE Division) also conducted bottom-trawl surveys that covered three areas during the summer of 2010: the EBS shelf area (with a special extension this year to the north), the EBS slope-region, and the Aleutian Islands region. Groundfish bottom-trawl surveys for the GOA are presently on a biennial cycle with the next one planned for summer.

The Ecosystem Considerations appendix to the SAFE report was revised substantially and a new more easily accessible format adopted. Hot topics that were highlighted for consideration during quota recommendations included incidental takes of short-tailed albatross and an update on Steller sea lion area-specific abundance trends. A special ecosystem synthesis team met and selected 10 indicators for the Bering Sea to present to the Council this year:

- North Pacific Index: Strength of Aleutian Low relates to wintertime temps
- Eastern Bering Sea ice retreat: Influences timing of spring bloom, cold pool extent, and summer surface temps.
- Zooplankton - euphausiid hydroacoustic data and copepod index: Index of forage for planktivorous fish, seabirds, marine mammals
- Motile epifauna aggregate biomass
- Benthic foragers aggregate biomass
- Pelagic foragers aggregate biomass
- Fish apex predators aggregate biomass
- St. Paul fur seal pup production: Females foraging ranges on the shelf
- Thick-billed murre reproductive success on St. George: Central place foragers, don't migrate far outside EBS during winter
- Maximum potential trawl area disturbed: Index of habitat disturbance

These indicators were provided with a goal to summarize critical factors of the ecosystem and guide fishery management. A summary of the Bering Sea ecosystem report card was as follows:

- A strong la Niña has formed on the Equator as reflected in the recent downward trend in the North Pacific Index. The prediction for the Bering Sea is above average sea-ice extent and duration in winter and spring 2011. This would result in a fifth year of extensive ice over the southern Bering Sea shelf.
- The euphausiid biomass index increased more than threefold from 2004 to 2009 and then decreased in 2010 by approximately 30%. Large copepod biomass increased tenfold from very low values during the recent 2002-05 warm period to 2009. This suggests that overall food availability for planktivorous species is high. Age-0 pollock and other planktivorous species may be dependent on the availability of sufficient prey to generate enough lipids to survive their first winter. Thus, we predict that the survival of this particular year class of fishes might be better than average.
- Current (2005-10) mean biomass, catch, and exploitation rates of motile benthic epifauna and benthic foraging fish have been within one standard deviation of 1977-2010 levels. No trend is apparent in recent years for these foraging guilds.
- There is a concern with two of the commercial crab stocks in the mobile benthic epifauna guild which are overfished. However, this guild appears stable because the guild is dominated by non-target fish and invertebrate biomass.
- There are no apparent trends in benthic forager catch and exploitation rate. The benthic foragers guild appears stable and may not require further management action.
- Pelagic foragers have biomass below mean and exploitation rate above mean, but increasing trends in biomass and decreasing trends in catch and exploitation rates. The pelagic foragers guild biomass has been at a historic low, which has been a recent management concern. However, there are signs of recovery within the guild, as well as increased forage and positive physical conditions to support recovery. Continued caution with the management of species in this guild and continued monitoring may be necessary, but the outlook is improved from last year.
- The recent increasing trend in the apex predator guild biomass is driven largely by a decrease in Pacific cod biomass being offset by an increase in arrowtooth flounder biomass. The fish apex predators guild appears stable and may not require additional management action.
- Thick-billed murre reproductive success has increased during the past 5

years, concurrent with a colder Bering Sea, later ice retreat, and increased biomass of zooplankton on the outer shelf. Continued cold conditions in the Bering Sea will likely lead to favorable conditions for thick-billed murres nesting on St. George Island and a continued trend of higher reproductive success in 2011.

- Northern fur seal pup production on St. Paul Island has been declining since the mid-1990s, while it has been relatively stable on St. George since 2002. Estimated pup production on both Pribilof Islands in 2008 was similar to the level observed in 1916; however the population trends are different. In 1916, the northern fur seal population was increasing at approximately 8% per year following the cessation of extensive pelagic sealing, while currently (1998 through 2008), northern fur seal pup production on both Pribilof Islands is decreasing at approximately 6% per year.

In 2011 the ecosystem team will provide a similar synthesis and report card for the GOA region.

Fisheries for these groundfish species during 2009 landed 1.52 million t valued at approximately $1.7 billion after primary processing (Economic Chapter). This represents nearly half of the weight of all commercial fish species landed in the United States. The bulk of the landings are from eastern Bering Sea (EBS) pollock stock which has declined since 2007 from previous years but totaled about 810,000 t. Many of the flatfish stocks (e.g., rock sole, Alaska plaice, and arrowtooth flounder) remain at high levels but catches are relatively low. Yellowfin sole abundance is high but a larger fraction of the ABC is caught compared to other flatfish stocks in the EBS. Atka mackerel abundance biomass is variable but apparently strong incoming year-classes have the stock at above-average levels. Rockfish species comprise 5%-8% of the groundfish complex biomass and are generally increasing based on recent surveys. Presently, projections of 2011 spawning biomass for the main groundfish stocks are estimated to be near or above their target stock size (B_{MSY}) for both the BSAI and GOA regions (Fig. 2). The following present some assessment highlights by area and for select species.

GULF OF ALASKA (GOA)

In the GOA, assessments for 19 stocks or stock groups were completed. Since new primary groundfish survey data were unavailable, full assessments were presented only for pollock, Pacific cod, sablefish and "other species" groups. For longer-lived species, executive summaries were presented. The fishery management plan (FMP) for GOA groundfish has been modified (Amendment 79) so that the OFL and ABC levels for the "other species" complex in the GOA could be specified. Previously the FMP simply set the TAC at or below 5% of the sum of the target TACs without consideration of the potential impact on stocks within the "other species" category. In this year's SAFE report separate assessments were presented for sculpins, squid, octopus and sharks. These provide the basis for setting the OFL and ABC levels for this complex. The sum of the recommended ABCs for 2011 is 587,525 t, which represents a 4% increase from the 2010 total. The largest contributor to this increase was due to improved stock conditions for Pacific cod and pollock (Table 1).

For most stocks, the Council established TACs equal to ABCs with some exceptions. These exceptions include Pacific cod, where

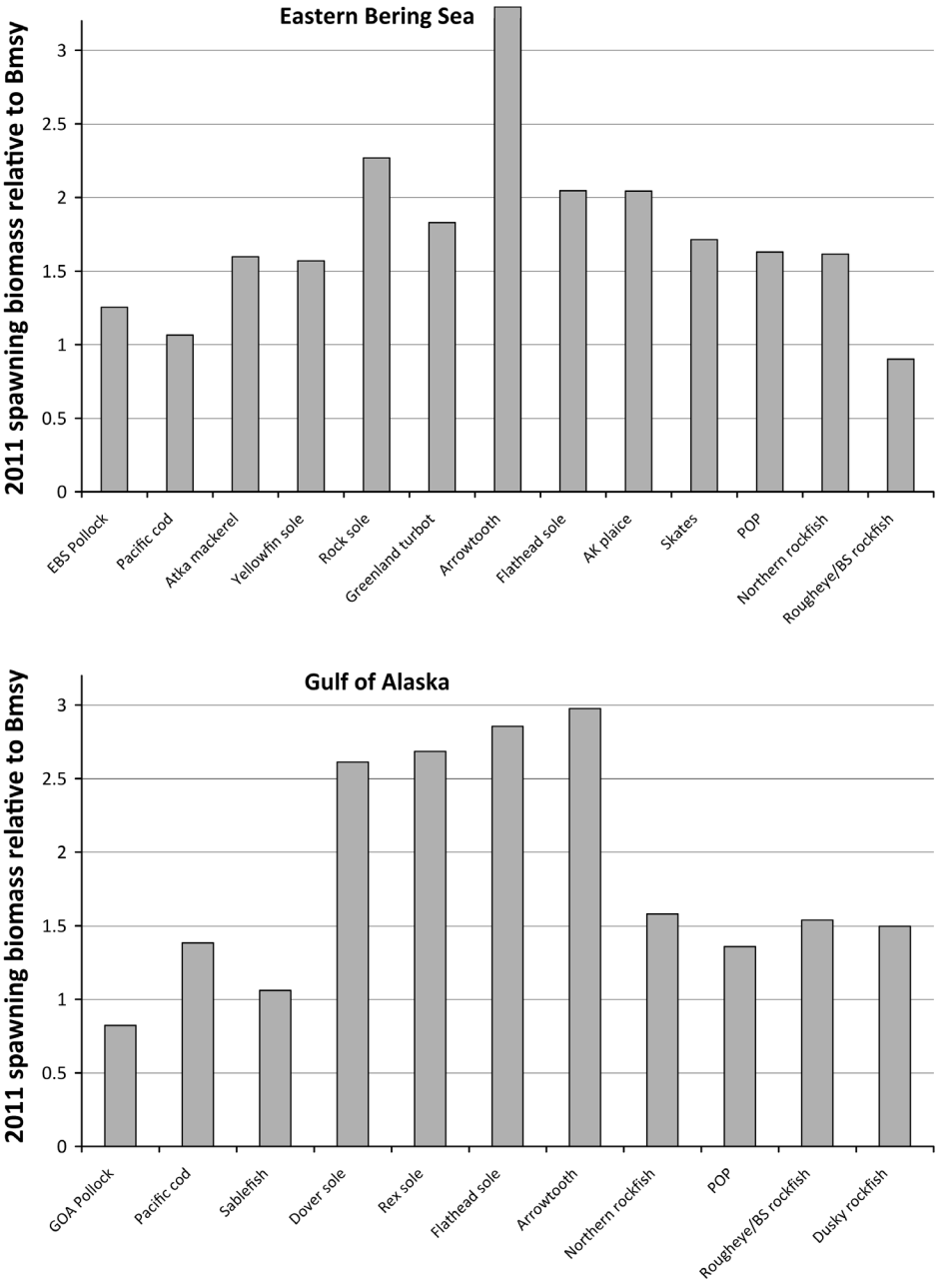


Figure 2. Relative 2011 spawning stock size compared to B_{msy} (taken to be $B_{35\%}$ for all species except EBS pollock) for the BSAI region (top panel) and for the GOA (bottom panel).

the quota was reduced approximately 24.4% to account for removals in the state-managed fishery, and those fisheries where the bycatch of other target species is a concern, specifically for shallow-water flatfish (Western and Central GOA), flathead sole (Western and Central GOA), arrowtooth flounder (GOA-wide) and other slope rockfish (East Yakutat/Southeast Outside). For those fisheries, the TAC was set below the ABC. Atka mackerel was also established at levels to meet incidental catch needs in other fisheries only (no directed fishing is allowed). Brief summaries of the full assessments for the GOA species or species group follows.

GOA Pollock: The 2008 Shelikof Strait echo integration-trawl (EIT) survey was the first conducted using the NOAA ship *Oscar Dyson*. The 2008 biomass estimate for Shelikof Strait was 15% higher than the 2007 estimate. In winter of 2007, a vessel comparison experiment was conducted between the NOAA ship *Miller Freeman* (MF) and the *Oscar Dyson* (OD), which obtained an OD/MF ratio of 1.132. These results suggest that biomass was relatively constant from 2007 to 2008. Biomass estimates of Shelikof Strait fish ≥43 cm (a proxy for spawning biomass) decreased by 52% from the 2007 estimate, apparently due to below average recruitment to the spawning population. However, the 2008 ADF&G crab/groundfish survey biomass estimate increased 9% from 2007. Despite the significant difference in the ratio of pollock backscatter between the *Miller Freeman* and the *Oscar Dyson*, the impact on assessment results and recommended ABCs was minor regardless of the modeling approach. The 2009 spawning biomass and ABCs varied 5%-7% across different model configurations, while population biomass varied by about 3%. The assessment results provided an estimated 2009 spawning biomass of 132,810 t, or 22% of unfished spawning biomass. Projections in stock estimates in recent years generally show increases that have not been realized. This could be due to a number of factors including the use of average recruitment in the current projection while below average recruitment is occurring, and juvenile natural mortality may be higher than assumed. While the short-term outlook indicates that the stock should increase, added conservation measures were made in recommending an ABC level for GOA pollock.

GOA Pacific Cod: Extensive work on the GOA Pacific cod model has occurred during the past year with draft assessments presented at both the September and November Plan Team meetings. Changes to the input data include updated catch data; recompilation of the pre-1990 fishery size composition data; updating the ageing error matrix; recompilation of the weight-at-length time series; updating the 2007 seasonal catch-per-unit-effort data from the longline, pot, and trawl fisheries; and splitting each trawl survey abundance estimate and size composition into fish smaller than 27 cm (referred to as the "sub-27" survey) and fish 27 cm and larger (referred to as the "27-plus" survey). New data to the model included age composition and length-at-age data from the 1987, 1990, and 1993 GOA shelf bottom trawl surveys, and preliminary catch rates for the 2008 longline and pot fisheries.

The Council-selected model resulted in a 2009 spawning biomass of 88,000 t, or 34% of unfished spawning biomass. Results also suggested that the spawning biomass will increase dramatically in subsequent years because of the 2006 year class which was estimated to be the highest on record. The extent of the rate of increase depends on the magnitude of this year class which was extremely uncertain being based solely on length frequencies collected in the 2007 trawl survey. The 2009 GOA trawl survey will be critical to better estimate the magnitude of the 2006 year class.

GOA/BSAI Sablefish: The survey abundance index increased 2% from 2008 to 2009, following a 16% decrease from 2006 to 2008. Similar to last year, the fishery abundance index was up 5% from 2007 to 2008 (2009 data will become available in early 2010). The spawning biomass is projected to decline from 2010 to 2012 and then stabilize. The GOA 2009 trawl survey estimate was 2% lower than the 2007 estimate, and the 2010 spawning biomass is estimated to be about 35% of unfished biomass. This compares with levels during 1998 - 2001 of about 29%. The 2000 year

Table 1. The 2010 catch levels compared to the 2010 and 2011 ABC specifications and change in ABC (in metric tons (t)) for the groundfish species types for the Gulf of Alaska. Note that "Other species" ABCs were specified for the first time in 2009 and for 2011 are broken and managed by component groups.

		ABC			
Species	2010 Catch	2010	2011	Change	
Pollock	75,189	84,745	96,215	up 11,470	14%
Pacific cod	58,660	79,100	86,800	up 7,700	10%
Sablefish	9,998	10,370	11,290	up 920	9%
Flatfish	12,757	119,583	121,245	up 1,662	1%
Arrowtooth flounder	23,015	215,882	213,150	down 2,732	-1%
Rockfish	24,870	35,771	34,653	down 1,118	-3%
Atka mackerel	2,409	4,700	4,700	same	0%
Skates	4,944	8,273	8,273	same	0%
Other species	1,793	7,075	11,199	up 4,124	58%
Total	213,635	565,499	587,525	up 22,026	4%

class appears to be larger than the 1997 year class, and these two year classes compose the bulk of the spawning biomass.

The recommended 2011 Alaska-wide sablefish ABC is 5% higher than the 2010 ABC. These recommendations were supported by a substantial increase in the 2010 domestic longline survey index in the eastern Gulf region. However, there was only a slight increase in estimates of incoming recruitment year classes, and the recommended ABC is projected to decrease by 8% in 2012. GOA trawl survey biomass estimates will be available for next year's assessment in addition to the longline survey index, and work continues on using statistical methods to adjust the longline survey index to account for sperm and killer whale depredation.

GOA Sharks: In an effort to provide better management advice for non-target species the Council and NMFS moved the "other species" management category into component groups. In particular, developing advice for setting shark catch limits was of particular interest. Presently, the Council's system for limiting catches of the most data-poor stocks is to use historical average catches. However, this approach poses difficulties for these stocks since catch records are less reliable. The Council through the Plan Teams and SSC are working with ABL scientists to arrive at the best approach for proper conservation of these species. In the GOA, the complex is dominated by spiny dogfish (on average 53% of the total shark catch). Unlike sleeper and salmon sharks, which comprise most of the remaining shark species in the complex, spiny dogfish are distinguished as having some estimate of natural mortality and trawl-survey biomass estimates are available. Presently, thanks to details presented in the stock assessment document, an interim approach to setting an ABC for this group was adopted. However, it is likely that when unaccounted bycatch of sharks in the halibut individual fishing quota (IFQ) fishery and state managed fisheries is estimated, alternative approaches will be taken into consideration in future shark assessments and quota recommendations.

GOA Octopus: As with sharks, both catch and survey estimates appear to be generally unreliable as a strong basis for setting ABCs for this stock complex. Novel approaches for providing better estimates of biomass are being developed. For the Council, the Plan Team and SSC recommended treating the survey estimates as a "minimum" biomass, which when applied to a conservative harvest rate (based on conservative assumptions about natural mortality) results in an octopus catch limit that will provide adequate protection. Importantly, the Council also recommended that octopus be set on bycatch-only status (i.e., no directed fishery will be allowed).

GOA Rockfish: Executive summaries were prepared for all GOA rockfish in 2010 because this is an off-cycle (even) year where no new survey data are available. The ABC level declined slightly for Pacific ocean perch (587 t or -3%), northern rockfish (243 t or -5%), and pelagic shelf rockfish (305 t or -6%). For the rougheye/blackspotted rockfish (RE/BS) complex and the demersal shelf rockfish, ABC levels remained relatively steady, increasing slightly by 10 t (1%) and 5 t (2%), respectively. The ABCs for all other rockfish species groups were rolled over from last year. For next year, it was recommended that dusky rockfish be removed from the pelagic shelf rockfish complex and presented in a separate assessment because assessment of this species is based on an age-structured model. The remaining pelagic shelf species (widow and yellowtail rockfish) could then be combined with other slope rockfish and this complex could be renamed "GOA Other Rockfish." The SSC encouraged further exploration of this split and the assessment authors plan to present an alternative grouping scheme in September 2011. Information on genetic and non-genetic population structure for the RE/BS complex was included as an appendix to the executive summary. The report follows the stock structure template as recommended by the Stock Structure Working Group in September 2010. Analysis of this information suggested that stock structure did exist for the RE/BS complex, but it was likely that current management units were set at reasonable scales relative to the stock structure.

BERING SEA/ALEUTIAN ISLANDS (BSAI)

The sum of the ABCs for 2011 BSAI groundfish stocks, as recommended by the SSC, is about 2.53 million t, up by 19% from 2010 totals. This increase was driven mostly by the EBS pollock ABC (1.267 million t for 2011 compared to 813,000 t in 2010). Interestingly, nearly all major groundfish stocks increased in abundance in the EBS shelf trawl survey relative to 2010 estimates (Fig. 3). For the Aleutian Islands region, results were more variable with about the same number of stocks showing an increase relative to the 2006 survey (Fig. 4). Overall, even though slightly more stocks indicated a decrease relative to 2006, the combined increase in fish species was about 14%.

EBS Pollock: In summer 2010 a panel of three experts outside of NMFS was convened to review the assessment approaches used for this stock. They developed a series of reports which detailed recommendations for improvements. These reports were presented to the Plan Teams and Council during September and October and subsequently incorporated into the assessments for the December analyses.

Data on the EBS pollock stock showed improved conditions compared to 2009. The acoustic and bottom trawl surveys suggest that the 2006 and 2008 year classes are above average and because of that, the biomass is projected to increase to above B_{MSY} level in 2011. This resulted in an ABC increase of 14% over what was previously projected for 2011. The Council's Plan Teams and SSC noted that this was below the maximum permissible levels and cited a number of reasons why the added precaution was warranted which included uncertainty in the strength of two incoming year-classes (2006 and 2008). A new abundance index (covering 2006-09) using opportunistically-collected acoustic data from the bottom-trawl survey vessels was introduced in this year's assessment. The index may be useful in future years to fill in the gap-years when the survey vessel works elsewhere.

Aleutian Islands Pollock: Age composition data from the 2007 and 2008 opportunistic acoustic surveys were added to the model. In this year's analysis age-determination error was re-evaluated and found to provide improved fits to the available data. The 2010 survey indicated increased abundances throughout the Aleutian Islands. The largest increase occurred in the eastern area.

BSAI Pacific Cod: Considerable effort to respond to the public and the Council comments on the Pacific cod assessment continued in 2010 with meetings in May, and September-December. Survey data indicate that after all-time lows from 2006 through 2008, the 2009 Bering Sea survey biomass for Pacific cod was slightly higher than the 2008 estimate, and the 2010 biomass estimate was more than double the 2009

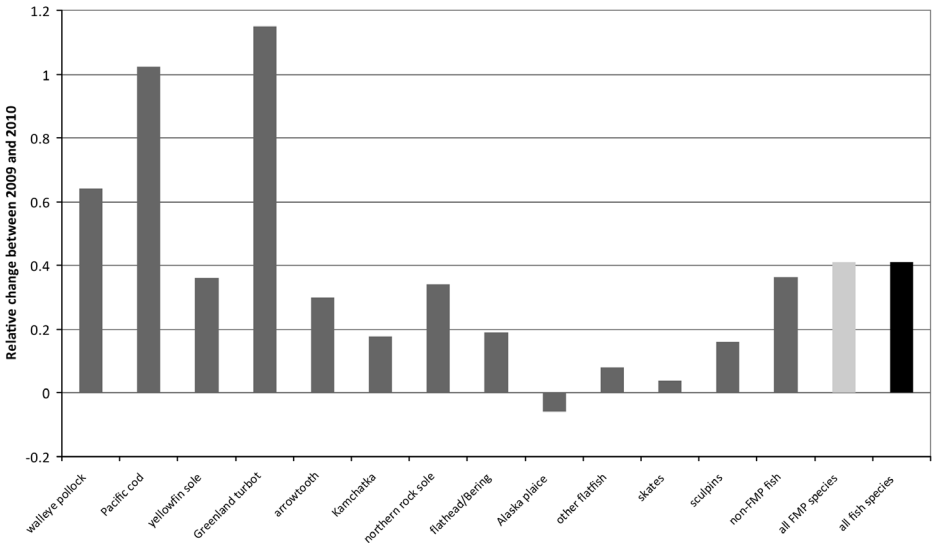


Figure 3. Relative change in survey estimates of major groundfish for the eastern Bering Sea shelf bottom trawl survey. (Note: Invertebrates were omitted; rockfish, Atka mackerel, and sharks were included in the total.)

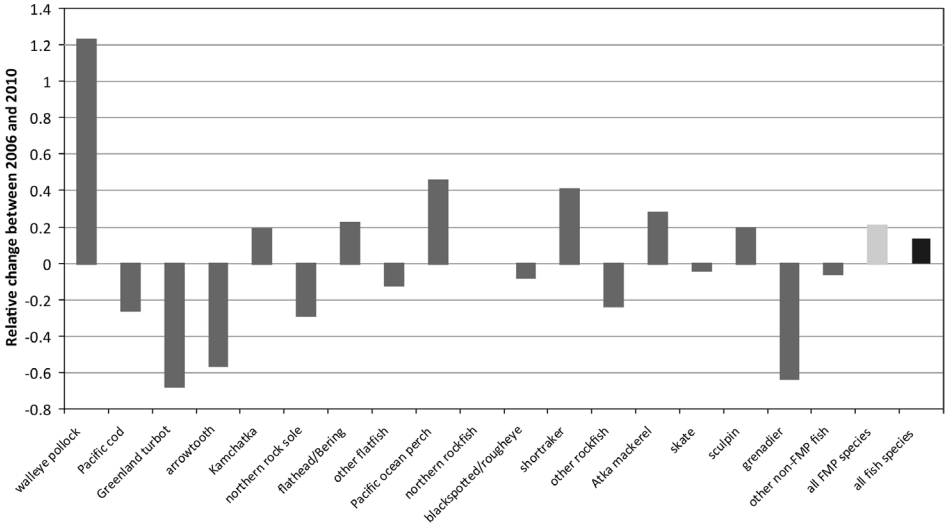


Figure 4. Relative change in survey estimates of major groundfish for the Aleutian Islands bottom trawl survey. (Note: The southern Bering Sea portion of the survey was included, invertebrates other than squid and octopus excluded, and sablefish, squids, sharks, and octopus were included in the totals.)

estimate. The 2006 and 2008 year classes appear to be strong, and stock abundance is expected to increase substantially in the near term. The Pacific cod ABC for 2011 increased by 35%, relative to the 2010 value, to 235,000 t.

BSAI Yellowfin Sole: The 2010 EBS bottom trawl survey biomass estimate increased 36% from the low estimate of 2009 but is more consistent with the levels estimated for 2006–08. The stock assessment model indicates that yellowfin sole have slowly declined over the past 20 years, although they are still at a fairly high level (73% above B_{MSY}), due to recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 1970s. The time-series of survey age compositions indicate that only 5 of the past 20 year classes have been at or above the long-term average. However, the 2003 year class appears to be as strong as any observed since 1983 and should contribute to the reservoir of female spawners in the near future. The 2010 catch of 119,000 t represents the largest flatfish fishery in the world and the 5-year average exploitation rate has been 4% for this stock (consistently less than the ABC).

BSAI Northern Rock Sole: This stock is currently at a high and increasing level due to strong recruitment from the 2001, 2002, and 2003 year classes which are now beginning to contribute to the mature population biomass. The 2010 bottom trawl survey resulted in a biomass estimate of just over 2 million t, 34% higher than the 2009 point estimate. The northern rock sole harvest primarily comes from a high value roe fishery conducted in February and March which usually takes only a small portion of the ABC because it is constrained by prohibited species catch limits and market conditions. The stock assessment model indicates that the stock declined in the late 1990s and early 2000s due to poor recruitment during the 1990s but is now projected to increase in the near future due to the recently observed strong recruitment. It is currently estimated at twice the B_{MSY} level.

BSAI Flathead Sole: Data on the flathead sole stock showed improved conditions compared to 2009. Bottom trawl survey estimates of total biomass for 2010 were 19% higher than for 2009. The 2007 year class is estimated to be above average, but it follows 3 years of poor recruitment. As a consequence, ABC for 2011 is only slightly (0.2%) higher than last year.

BSAI Alaska Plaice: This resource continues to be estimated at a high and stable level with very light exploitation. The 2010 survey biomass was 498,000 t, a bit lower than the 2009 estimate but consistent with estimates from resource assessment surveys conducted since 1985. Of interest in 2010 is that the combined results of the eastern Bering Sea shelf survey and the northern Bering Sea survey indicate that 38% of the Alaska plaice biomass was found in the northern Bering Sea in 2010. The stock is expected to increase further in the near future due to the presence of a strong year class estimated from 2002. Exploitation occurs primarily as bycatch in the yellowfin sole fishery and has averaged only 1% from 1975 to 2010. A revised (lower) estimate of natural mortality was applied to the assessment which affected some reference points and stock projections.

BSAI Greenland Turbot: The 2010 EBS shelf trawl survey biomass estimate was more than double the 2009 estimate, the highest biomass since 2003. More significantly, the population numbers were the highest ever recorded (since the standard survey began in 1982). The total 2010 population estimate (in numbers, all ages) from the EBS survey was over five times the average for Greenland turbot. The high numbers were almost entirely due to indi-

cations of 1-year old Greenland turbot in this survey. While the EBS region is showing good signs of Greenland turbot, the 2010 Aleutian Islands survey is the lowest on record and about one-third of the value estimated in 2006. This may be a concern because in recent years the proportion of Greenland turbot taken in the Aleutian Islands has increased significantly.

BSAI Arrowtooth and Kamchatka Flounder: The year 2010 was unique in that the Bering Sea shelf, slope, and the Aleutian Islands were all surveyed in the same year. Since arrowtooth flounder are present in all these waters, a good update was available for arrowtooth flounder stock status. The combined survey estimates indicate that the stock is in an upward trend in all areas and the stock assessment model indicates that the resource has steadily increased from a low biomass in the late 1970s to a very high current biomass. Good recruitment from 7 of the 10 years from 1998 to 2007 combined with light exploitation should continue this trend.

Increasing interest in harvesting Kamchatka flounder has caused a concern about managing both species under a single ABC. Although Kamchatka flounder compose only 7% of the composite *Atheresthes* biomass, there has been a disproportionate harvest in recent years whereby the potential exists to overharvest Kamchatka flounder under the present combined management. Beginning in 2011, Kamchatka will be assessed separately from arrowtooth flounder and receive an individual ABC and TAC.

BSAI Rockfish: This group comprises 4% of the BSAI Groundfish complex. Pacific ocean perch (POP) and northern rockfish dominate, with most of the biomass in the Aleutian Islands. For POP, the biomass estimates increased with the 2010 Aleutian Islands bottom-trawl survey estimates and additional age composition data.

The recommended ABC increased by 31% from the 2010 value due to the high 2010 survey biomass estimate and the generally increasing trend of the estimates since 2002. The northern rockfish survey biomass estimates show a slightly increasing trend, starting at 92,000 t in 1977 and increasing gradually to around 200,000 t since 2000. The BSAI northern rockfish ABC increased from the 2010 value by about 20% to 8,670 t.

Fish previously referred to as rougheye rockfish are now recognized as consisting of two species, the rougheye rockfish (*Sebastes aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*). The current information on these two species is insufficient to support species-specific assessments. The blackspotted and rougheye complex was assessed with an age-structured model which showed a high-degree of recruitment variability. The authors showed that assumptions about the level of recruitment variability allowed affects the reference points for this species complex and consequently ABC recommendations. Shortraker rockfish biomass estimates were similar to previous years, consequently the change in ABC was minor (<2% increase). However, the "other rockfish" category ABC increased by 26% based on new survey data (to 1,348 t).

BSAI Atka Mackerel: The projected age 3+ biomass at the beginning of 2011 is estimated at 437,600 t, up about 13% from last year's estimate for 2010. The addition of the 2009 fishery age composition and the 2010 survey age composition impacted the estimated magnitude of the 1999 and 2000 year classes which both increased 17%, the 2001 year class which increased 22%, and the magnitude of the 2006 year class which increased 12% relative to last year's assessment. The projected female spawning biomass for 2011 is estimated at 146,000 t, which is 56% of unfished spawning biomass and above $B_{40\%}$ (104,400 t), thereby placing BSAI Atka mackerel in Tier 3a. The 2011 estimate of spawning biomass is up about 31% from last year's estimate for 2010. It should be noted that the projected female spawning biomass estimates for 2011 and 2012 assumed reduced catches under proposed SSL RPAs. The projected 2011 yield at $F_{40\%}$ = 0.384 is 85,300 t, which is 15% higher than last year's estimate for 2010. Despite the decrease in the estimate of $F_{40\%}$, the biomass estimates are up relative to last year's projections, resulting in increased $F_{40\%}$ yields.

BSAI Sharks: In the BSAI, catch is dominated by Pacific sleeper sharks (on average 68% of the total shark catch), a species for which researchers know very little. While Pacific sleeper sharks may be relatively well sampled by the various trawl surveys, there is not an estimate of natural mortality. Therefore, this species cannot be managed under Tier 5. Thus, all shark species in the BSAI are Tier 6 species. Unlike the GOA, bycatch in unobserved fisheries is not a major concern, but the declining trends in commercial catch and research indices may be a concern and will be examined for the next assessment. Stock assessment authors are striving to develop an estimate of natural mortality for Pacific sleeper sharks so that they may be considered for Tier 5.

By Jim Ianelli

AGE & GROWTH PROGRAM

Production Numbers

Estimated production figures for 1 January–31 December 2010. Total production figures were 36,210 with 8,005 test ages and 314 examined and determined to be unageable.

Species	Specimens aged
Alaska plaice	608
Arrowtooth flounder	1,615
Atka mackerel	1,742
Blackspotted rockfish	229
Dover sole	468
Dusky rockfish	606
Flathead sole	1,970
Giant grenadier	784
Greenland turbot	922
Northern rock sole	3,394
Northern rockfish	773
Pacific cod	1,961
Pacific ocean perch	2,121
Rex sole	875
Rock sole unidentified	631
Rougheye rockfish	746
Sablefish	2,357
Southern rock sole	2,257
Walleye pollock	10,875
Yellowfin sole	1,276

By Jon Short