Auke Bay Laboratories (ABL)

HABITAT AND MARINE CHEMISTRY PROGRAM

Saffron Cod (*Eleginus gracilis*) in Shallow-Water Habitats of Prince William Sound, Alaska

ABL scientists have identified saffron cod (*Eleginus gracilis)* (Fig.1) as one of the dominant fish species in shallow-water habitats (<5 m deep) of western Prince William Sound (PWS), Alaska. Saffron cod have not been reported in PWS, and their appearance suggests changes have occurred in fish community structure in shallow-water habitats. An estimated 15,910 saffron cod were captured in 49 of 95 beach seine hauls at eight locations in PWS in 2006 and 2007. Saffron cod accounted for 32% of the total fish catch (49,060 fish, 45 species). Abundance of saffron cod differed by season and habitat type; catch was greater in summer and fall than in spring, and fish were captured almost exclusively in eelgrass (*Zostera marina*). Most saffron cod captured were age-0; based on age from otoliths, mean size of age-0 fish increased from 70 mm total length (TL) (n = 8) in July to 108 mm TL (n = 21) in September. Age≥1 saffron cod consumed larger and fewer varieties of prey than age-0 fish and targeted predominately epibenthic fauna, whereas age-0 fish consumed predominately pelagic fauna. Most saffron cod leave shallow-water habitats by late summer or early fall; of 1,002 fish fin-clipped and released at one sampling location in July 2007, only 2 fish were recaptured in August 2007. The appearance of saffron cod in western PWS could be further evidence of community reorganization from an ocean climate regime shift in the late 1970s that favored other gadid populations in the northern Gulf of Alaska.

By Scott Johnson

Diel Use of Nearshore Habitats by Fishes in Late Summer in Prince William Sound, Alaska

To determine if there were differences in diel use of nearshore habitat, fishes were sampled diurnally and nocturnally at six locations in western Prince William Sound, Alaska in late August 2007. At each location, fish were sampled at low tide with a beach seine in one eelgrass and one understory kelp site; day and night sampling was separated by approximately 62 hours. A total of 1,181 fish representing 31 species were captured; 629 fish representing 20 species during daytime sampling and 552 fish representing 30 species at night. Catches between the day and night were similar, but species composition and mean size of fish changed. Species richness was similar in eelgrass during the day and night (mean = 6 species/site during the day and 7 at night), whereas in kelp, species richness was greater at night (mean = 8 species/site) than during the day (mean = 4 species/site). Mean length of fish was greater at night (112 mm) than during the day (101 mm) in eelgrass and was greater at night (114 mm) than during the day (58 mm) in kelp.

Saffron cod, tubesnout, crescent gunnel, manacled sculpin, bay pipefish, Pacific herring, and padded sculpin accounted for about 90% of both day and night catches in eelgrass and kelp. In eelgrass, saffron cod was the most abundant species during the day (57% of catch) and night (40% of catch). In kelp, herring was the most abundant species during the day (38% of catch), and saffron cod was the most abundant species at night (42% of catch). Diel sampling indicates similar fish abundance in nearshore vegetated habitats during both day and night, but mean size of fish was greater, and number of fish species increased in kelp habitat at night.

By John Thedinga

Figure 1. Saffron cod (*Eleginus gracilis)* captured with a beach seine in western Prince William Sound, Alaska, in summer 2007.

MARINE SALMON INTERACTIONS PROGRAM

2008 NOAA Pink Salmon Forecast "Spot On" for Southeast Alaska

Auke Bay Laboratories' pink salmon forecast for the commercial harvest in Southeast Alaska (SEAK) proved highly accurate in 2008, correctly predicting record low returns to the region. At the SEAK regional Purse Seine Task Force (PSTF) meeting in November 2007, researchers from ABL predicted a harvest of 16.1 million pink salmon for 2008. In the ensuing year, 15.9 million pink salmon were harvested in the region, 98% of the predicted forecast. Remarkably, this 2008 SEAK pink salmon harvest was the second lowest in the past 20 years. Scientists from ABL have been forecasting pink salmon harvests in SEAK for the past 5 years and are working to develop forecasting models for other salmon species. At the PSTF meeting in December 2008, ABL researchers forecasted a 44.4 million pink salmon harvest in SEAK for 2009 (http://www.afsc.noaa.gov/ABL/MSI/msi_sae_psf.htm).

The ABL pink salmon forecasts are based on ecosystem monitoring research conducted over the past 12 years under the Southeast Alaska Coastal Monitoring (SECM) project (http://www.afsc.noaa.gov/ABL/MSI/msi_secm.htm). For the past 3 years, the Alaska Department of Fish and Game (ADF&G) has also been using SECM data to refine their pink salmon forecast estimates for SEAK. A further continuation of SECM research over a longer time series will enable analysis of year-class variation for salmon species with more complicated and prolonged ocean life histories. Some of these species have recently experienced declines. In 2008, for example, sockeye salmon, which generally spend two or three winters at sea, returned to SEAK in numbers reported to be the second lowest in nearly 50 years.

Until recently, the NOAA ship *John N. Cobb* served as the foundation of this ongoing SECM research. However, after 58 years of federal service as an Alaska research vessel, the *Cobb* was decommissioned in 2008. No specific plan or time schedule has been developed for a *Cobb* replacement vessel to date. Consequently, the continuation of this SECM research depends on availability of charter funds to replace the *Cobb*.

Additionally, these charter funds would need to be in place in an adequate time frame to advertise for a prospective trawl vessel to bid and be contracted for this research by early summer 2009.

By Joe Orsi

MARINE ECOLOGY & STOCK ASSESSMENT PROGRAM

Changes In Body Composition and Fatty Acid Profile During Quillback Rockfish (*Sebastes maliger*) Embryogenesis

Researchers from ABL's Marine Chemistry and Marine Ecology Programs investigated developmental changes in the body compositions and fatty acid (FA) profiles of embryos and preparturition larvae of the quillback rockfish (*Sebastes maliger*). Comparisons of proximate composition data from early-stage embryos versus hatched, preparturition larvae taken from wild-caught gravid females indicated that embryos gain over one-third their weight in moisture while consuming 20% of their dry tissue mass for energy as they develop into larvae. Lipids contributed 60% of the energy consumed and were depleted more rapidly than protein, indicating a protein-sparing effect. Oil globule volume was strongly correlated with lipid levels, affirming its utility as an indicator of energetic status. The FA profiles of early embryos differed significantly from those of hatched larvae. Differences in the relative abundances of FAs between early embryos and hatched larvae indicated different FA depletion rates during embryonic development. We conclude that some metabolically important FAs may prove useful in assessing the condition of embryos and preparturition larvae, particularly the FA 20:4n-6, which cannot be synthesized by many marine fish and which was conserved during embryogenesis. Variability in body composition and energy use among rockfish species should be considered when interpreting any measures of condition.

By Fletcher Sewall

2008 Sablefish Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 2008. The survey is a joint effort involving the AFSC's Auke Bay Laboratories 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 2008, the thirtieth annual longline survey of the upper continental slope of the Gulf of Alaska and eastern Aleutian Islands was conducted. One hundred-forty-eight longline hauls (sets) were completed during 4 June–1 September 2008 by the chartered fishing vessel *Alaskan Leader*. Sixteen kilometers (km) 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*), arrowtooth flounder (*Atheresthes stomias*), and Pacific cod (*Gadus macrocephalus*). A total of 74,257 sablefish were caught during the survey. Sablefish, shortspine thornyhead, Greenland turbot (*Reinhardtius hippoglossoides*), spiny dogfish (*Squalus acanthias*), and lingcod (*Ophiodon elongatus*), were tagged and released during the survey. To date, 221,167 sablefish have been tagged during the survey time series with 17,261 recoveries. Length-weight data and otoliths were collected from 2,003 sablefish. Killer whales (*Orcinus orca*) took fish from the longline at three stations in the Aleutian Islands region and two stations in the western Gulf of Alaska. Sperm whales (*Physeter macrocephalus*) were often present during haulback and were observed depredating on the longline at 18 stations in the eastern Gulf and 3 stations in the central Gulf of Alaska. This is the highest incidence of sperm whale interactions ever encountered during the survey. Occurrence of depredation in the eastern Gulf has ranged from 10% of sampling days that sperm whales were present in 2001 to 90% in 2008.

Several special projects were conducted during the 2008 longline survey. Spiny dogfish and lingcod 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. Yellow Irish lords were sampled for maturity information in the Aleutian Islands to help support sculpin life history studies. Finally, a 2-day gear experiment was conducted near Yakutat to compare the catching efficiency of standard, hand-baited survey gear to auto-baited gear.

By Chris Lunsford

Deepwater Longline Study for Giant Grenadier and Sablefish

In August 2008, ABL used the chartered commercial longline vessel *Beauty Bay* to conduct a deepwater longline survey feasibility study in the western Gulf of Alaska. The objective was to investigate the abundance and biological characteristics of giant grenadier and sablefish in deep waters of the Gulf of Alaska that have not been previously sampled in fishery surveys. Longline and trawl surveys in Alaska both indicate that these two species are by far the most abundant fish at depths 400-1,000 m on the continental slope, but their abundance in deeper water is unknown. The study consisted of fishing five longline stations on 6-10 August east of Dutch Harbor at depths up to 1,620 m. However, due to vessel mechanical problems and the difficult fishing conditions encountered at the deep-water stations, total fishing effort in the study was roughly 40% less than had been planned, and depth coverage was also less than ideal.

The study demonstrated that fishing longlines in deep water can present special problems and that extra fishing effort may be needed to compensate for these problems. Because of the limited fishing effort and incomplete depth coverage, results of the study were not conclusive. However, catch rates of sablefish were extremely low, and those of giant grenadier were relatively high. This suggests that biomass of sablefish at depths greater than 1,000 m in the western Gulf of Alaska is probably inconsequential, whereas considerable biomass of giant grenadier may exist at these depths. An unexpected finding of the study was the large abundance of another grenadier species, Pacific grenadier, at some of the deep-water stations. At one station, Pacific grenadier were caught on 56% of the hooks that were set.

By Dave Clausen

Groundfish Stock Assessments

This quarter, scientists from ABL's MESA Program completed four full stock assessments and five updated assessments for nine species/species groups of Alaska groundfish. Full assessments included Bering Sea/Aleutian Islands sharks, Gulf of Alaska sharks, Alaska grenadiers, and Alaska sablefish. Stock assessment updates included Gulf of Alaska Pacific ocean perch, northern rockfish, rougheye rockfish, pelagic shelf rockfish, and shortraker rockfish and other slope rockfish. Stock Assessment and Fishery Evaluation (SAFE) reports or executive summaries were prepared for each assessment, and results were presented to the North Pacific Fishery Management Council'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 2009. For detailed information about these assessments, see the Resource Ecology and Fisheries Management (REFM) Division section of this issue .

By Dana Hanselman

Fisheries Monitoring & Analysis Division (FMA)

REFRESHER SAFETY TRAINING FOR RETURNING OBSERVERS

In response to recent at-sea tragedies, the Fisheries Monitoring and Analysis Division (FMA) implemented an updated refresher safety training session for prior North Pacific Groundfish Observer Program (NPGOP) observers returning to work at sea. The safety training builds on the cold-water refresher training implemented in 2006 (see April-June 2006 *Quarterly Report*) and provides additional review of actual at-sea emergencies and several mock drill exercises to help observers improve their preparedness for an at-sea emergency. Lessons learned from the sinking of the fishing vessels *Alaska Ranger* in March 2008 and *Katmai* in October 2008 were included in the training materials.

As described in the April-June 2008 *Quarterly Report*, all NPGOP observer trainees complete 20 hours of safety training during their initial 3-week training class. During recurrent training for experienced observers, safety issues are discussed, and all observers perform in-water safety drills at least once every 3 years.

Returning observers are required to attend an annual 4-day briefing class prior to their first deployment each calendar year. These classes provide observers with a review of sampling procedures and any new information they need to complete their duties in the field. In addition to the standard review of safety procedures and periodic in-water safety drills, the 2009 4-day briefing classes will include more comprehensive presentations and mock drills to better prepare observers for emergencies.

The dangers of exposure to cold water are reviewed through a video presentation and class discussion. This provides observers with an understanding of the effects of cold water exposure and methods to increase survivability and possibility of rescue should they find themselves involved in an in-water emergency either directly or indirectly through assisting a victim.

Immersion suits (also known as exposure suits) can prolong survival time in the cold waters of the North Pacific. Due to the importance of properly donning an immersion suit prior to entering the water, observers participate in drills to don their immersion suits quickly under a variety of scenarios.

Training includes discussion of safety considerations when embarking or disembarking a vessel. The dangers of this common activity are often overlooked. A slip or fall can result in injury or death, and observers are instructed to take action to minimize the possibility of such injury.

Rules governing when an observer must refuse to deploy on a vessel due to safety considerations are reviewed. Observers must receive a safety orientation and are required to complete a Vessel Safety Checklist before deploying on each vessel. The checklist provides documentation of the presence and condition of all safety equipment required by the U. S. Coast Guard onboard the vessel. All required safety equipment must be onboard, in working order, and those items with an inspection or expiration date must show a current date. The observer must refuse to leave the dock or board the vessel if the observer does not receive a safety orientation or specific criteria on the checklist are not met.

The classes also focus on emergency response procedures typical of vessels fishing in Alaska. Observers participate in reviewing the details that should be found on a vessel station bill (the vessel's emergency plan) and then split into groups to create a station bill for the subsequent drills. An abandon ship drill is also part of the classroom session with each observer playing a role. Groups perform drills one at a time

Observers practice in-water safety techniques in Lake Washington, Seattle, as FMA staff and others watch. Photo by FMA staff.

FMA staff member Jason Stern demonstrates the features of a life raft to observers. In the background, observers prepare for the in-water safety drills. Photo by FMA staff.

FMA staff members Kristy Lewis and Dan Decker monitor as observers practice entering the water while wearing an immersion suit. Photo by FMA staff.

and with differing scenarios while others watch the drill so that all can participate in follow-up discussions reviewing what was learned in each drill.

Following performing drills in the classroom setting, the observers head to the water for more realistic drills. The first drill is an in-water drill. This is a complete abandon ship drill, starting with the observers located dockside or poolside, and includes sounding the alarm, sending a MAYDAY, mustering at an assigned station, donning an immersion suit, entering the water while wearing an immersion suit, swimming to and entering a life raft, and exiting the raft. The in-water exercise also includes familiarization with the confined space experienced inside of a life raft.

Observers also participate in a Man Overboard rescue simulation. In this exercise they practice tossing a life ring to within "arm's reach" of a buoy in the water but avoiding hitting the buoy, while the observers keep track of the buoy visually and point to the buoy as would be done at sea to keep the person in the water in view.

These presentations and drills address situations and lessons learned from actual at-sea emergencies. At the end of the drills, the class discusses the activities to review what was done well and areas needing improvement. Through these efforts, FMA assists observers in being well prepared for life at sea.

By Allison Barns

Habitat & Ecological Processes Research Program

ESSENTIAL FISH HABITAT PROPOSALS REVIEWED

Proposals for FY09 Essential Fish Habitat (EFH) funding recently were solicited from Alaska Fisheries Science Center and NMFS Alaska Regional Office staff. Project selection for EFH research is based on research priorities from the EFH Research Implementation Plan for Alaska. Approximately $450,000 is spent on about 10 EFH research projects each year. Research priorities are

1. Coastal areas facing development.
2. Characterization of habitat utilization and productivity.
3. Sensitivity, impact, and recovery of disturbed benthic habitat.
4. Validation and improvement of habitat impacts model.
5. Seafloor mapping.

The Habitat and Ecological Processes Research (HEPR) team completed a scientific rating of the 2009 proposals in mid-November. Alaska Regional Office Acting Deputy Regional Administrator Jon Kurland and HEPR Program Leader Mike Sigler agreed on rankings based on the scientific review and management priorities. One change from previous years is that habitat recovery rate proposals were given higher priority this year. In past solicitations, few studies were proposed to estimate recovery rates of corals and sponges, yet these estimates are needed for habitat

Table 1. Essential Fish Habitat proposals recommended for funding for Fiscal Year 2009.

Cost ($)	Principal Investigators	Title
$ 105,900	Malecha, Heifetz	Recovery of deep-water sponges and sea whips from bottom trawling
$ 12,000	Zimmermann, Floering, Van Syoc, Stabeno	Invertebrate colonization of Pacific Marine Environment Laboratory (PMEL) moorings
$ 38,000	Malecha, Stone	Recruitment and response to damage of an Alaskan gorgonian coral
$ 65,000	Johnson, Thedinga	Nearshore fish assemblages in the Arctic: establishment of monitoring sites in a rapidly changing environment from energy development and climate change
$ 20,000	Ryer, Laurel, Knoth	Contrasting predation intensity and distribution in two rock sole nursery areas: a principal factor controlling nursery productivity - Component A
$ 77,800	Yeung, Yang, McConnaughey	Characterization of benthic infauna community for modeling essential fish habitat in the eastern Bering Sea - reduced plan
$ 34,446	Bailey, Chan	Year 2: Assessing the physical and temporal aspects of pollock spawning habitat utilization in Shelikof Strait, Gulf of Alaska
$ 41,600	Laurel, Ryer, Parrish, Stoner, Knoth, Urban	Productivity, habitat utilization, and recruitment dynamics of Pacific cod
$ 23,200	Rooper, Heintz, Aydin, Boldt	Characterize habitat utilization and productivity for rockfish species
$ 8,000	Harris	Natural and man-made disturbance of eelgrass beds in northern southeastern Alaska: damage and recovery
$ 13,000	Ryer, Laurel, Knoth	Contrasting predation intensity and distribution in two rock sole nursery areas: a principal factor controlling nursery productivity - Component B
$ 68,000	Ormseth, Norcross, Holladay	Utilization of nearshore habitat by fishes in Nushagak and Togiak Bays (Bristol Bay)

impacts modeling. The management prioritization generally followed the science ranking but a few changes were made to reflect the relevance of the proposals for fishery management decisions.

Twelve projects were recommended for funding in the order shown in Table 1. Five of these projects are recovery rate studies, six are continuing EFH studies, and one is a new study.

By Mike Sigler

National Marine Mammal Laboratory (NMML)

ALASKA ECOSYSTEMS PROGRAM

Northern Fur Seal Research in Alaska

The National Marine Mammal Laboratory's (NMML) Alaska Ecosystems Program (AEP) conducted a number of studies on northern fur seals (*Callorhinus ursinus*) during 2008, with field components that began in June and continued until late November. The primary research objectives of monitoring population trends and investigating the ecology and health of the fur seal population on the Pribilof Islands (St. Paul and St. George) were accomplished through a variety of projects, including studies of pup condition, causes of mortality, and habitat use during the winter migration. However, the majority of the AEP's research efforts involved three projects that collected data on fur seal abundance, fine-scale foraging behavior of adult females in the Bering Sea, and age-specific vital rates of females on St. Paul Island.

Northern fur seal abundance and population trends were assessed on the Pribilof Islands during 2008 by obtaining counts of adult males and estimates of the numbers of pups born. Recently completed analyses of data collected during the summer indicated that, although the numbers of adult males increased, overall pup production has continued to decline on the Pribilof Islands. Numbers of adult males increased on both St. Paul and St. George Islands from 2007 to 2008. The total number of adult males (10,612 individuals) counted on the Pribilof Islands during 2008 represented an increase of 4.6%. The trend in the number of territorial males with females was even more notable, having increased by 14.2% from 2007 to 2008. Pup production estimates were obtained using a mark-recapture (shear-sampling) method, and data were collected at both St. Paul and St. George Islands during August. We estimated that 102,674 (SE = 1,084) pups were born on St. Paul Island and 18,160 (SE = 288) pups were born on St. George Island during 2008. Since 2006 when the previous estimates were obtained, pup production declined by 6.6% at St. Paul Island and increased by 6.4% at St. George Island. The combined pup production estimate for St. Paul and St. George Islands declined approximately 4.9% from 2006 to 2008. Since 1998, pup production at these primary Pribilof Island breeding colonies has declined at an annual rate of 5.2% (SE = 0.40) and is now at a level of production that was last observed around 1916. Pup production was also estimated at Sea Lion Rock, a small island approximately 500 m from St. Paul Island, for the first time since 2002. The estimated number of pups born in 2008 at Sea Lion Rock was 6,380 (SE = 80), which represents a decline of 22.8% since 2002.

Fine-scale foraging behavior studies of northern fur seals were conducted during August–October 2008 at St. Paul Island, expanding the efforts of a pilot project that was initiated during 2007 by Dr. Carey Kuhn (AEP). Specific objectives of the project were to obtain higher-resolution location and diving data during adult female foraging trips in the Bering Sea and to identify important feeding areas using stomach temperature telemetry technology in combination with the fine-scale movement and diving data. Twenty-nine females were captured and sedated with gas anesthesia for instrumentation during August 2008. Each female was equipped with a GPS tag (MK10-AF, Wildlife Computers), stomach temperature recorder (MK10-L), and VHF tag. Six of the females were followed for a single trip while the remaining animals were tracked for two to six trips each. Current analyses are focused on quantifying differences between tracking methods using standard Argos satellite data and GPS data (Fig. 1). The high-quality GPS data are also being used with a new movement model developed by Devin Johnson (AEP) to test methods to improve satellite tracking data analysis. Tracking female fur seals using the Argos satellite data yielded an average of 12.0 (± 2.9) locations per day and, even though the location data had previously been filtered to remove poor quality locations, the location error was estimated to range from 0.8 km to more than 45 km (Fig. 1). By contrast, GPS tracking resulted in a greater number of highly accurate at-sea locations per day (31.6 ± 16.0), making it possible to define fine-scale high resolution foraging habitat. In addition, the GPS location data were more consistently distributed throughout the day; on average, a location was acquired every hour. The maximum time between location acquisitions was significantly greater for Argos satellite data, averaging slightly less than 18 hours for all females, compared to an average of 8.2 hours for the GPS data. Preliminary analysis also showed that females retained stomach temperature telemeters for approximately twice as long (for up to 5 days) in 2008 than in 2007.

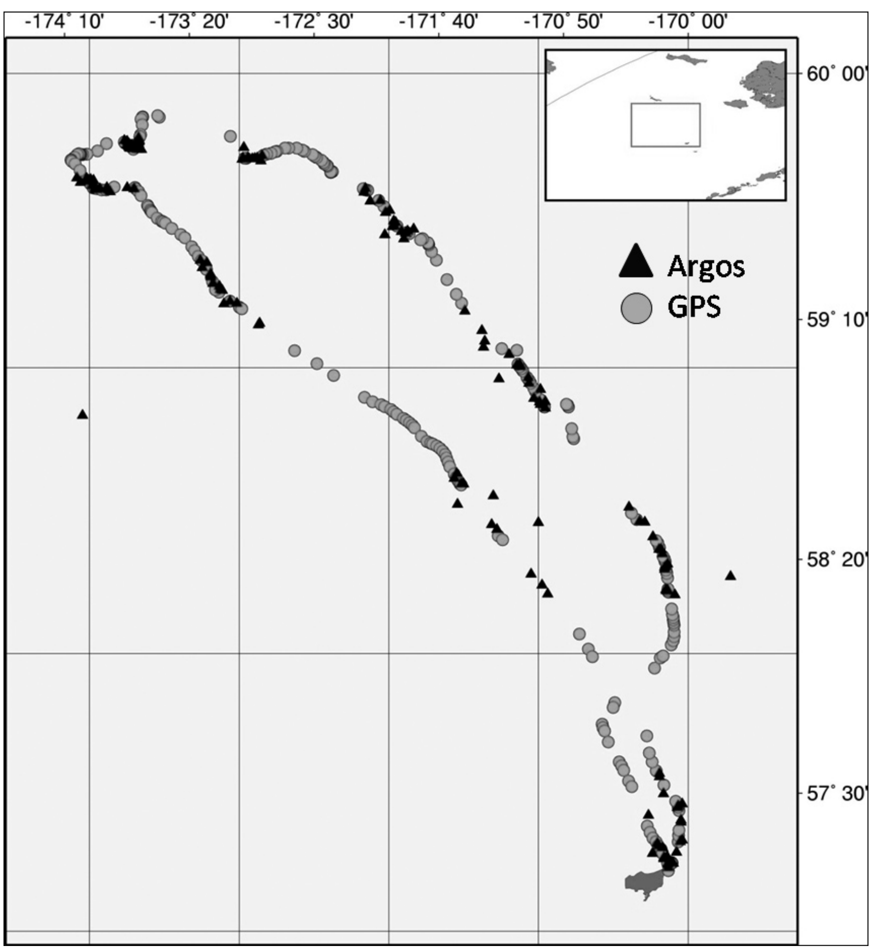


Figure 1. Argos satellite (triangle) and GPS (circle) locations acquired from an adult female northern fur seal during a summer foraging trip from St. Paul Island in 2008.

Research efforts by the AEP on age-specific vital rates of northern fur seals were expanded at St. Paul Island during 2008 and involved collaborations with biologists from Canada, Australia, and Scotland. Fieldwork at St. Paul Island focused on demographic objectives: tagging females for mark-recapture studies, extracting teeth for age estimation, reproductive ultrasonography to determine early-term pregnancy rates, and initiation of tag resighting and behavioral observations. Ninety-two females were captured 15–24 November, and 51 of these females were sedated with gas anesthesia for tooth extraction. Members of the AEP received training in tooth extraction techniques from Dr. Brad Page, a fur seal specialist from the University of Adelaide in Australia. Sixty-five of the captured females were also examined with ultrasound by reproductive specialists, Dr. Gregg Adams (University of Saskatchewan) and Dr. Don Bergfelt (U.S. Environmental Protection Agency). November is the period when embryonic diapause in fur seals ends and renewed growth of the embryo becomes detectable by either gross necropsy, in the case of animals historically collected for this purpose, or by ultrasonographic examination of the uterus of live females. Statistical modeling of the temporal progress of embryo growth and detection is part of the analysis of these data. However, our preliminary estimate of the pregnancy rate (83%) appears within the range expected for this period of November, and it is nearly identical to at-sea pregnancy rates observed in December–January during collections in the 1960s. The AEP will continue resighting work next summer to provide longitudinal data on survival and reproductive success of fur seals tagged in November.

By Rolf Ream

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

Passive Acoustic Monitoring

In 2007, NMML's Cetacean Assessment and Ecology Program (CAEP) began ramping up its use of passive acoustics to detect and monitor marine mammals, in collaboration with Sue Moore (NOAA Office of Science and Technology (S&T)–Pacific Marine Environmental Laboratory (PMEL)), Kate Stafford (Applied Physics Laboratory–University of Washington (APL–

UW)), and Dave Mellinger (Cooperative Institute for Marine Resources Studies (CIMRS), Oregon State University, and PMEL). Currently, there are acoustic components in the PRIEST (Pacific Right Whale Evaluation Study) and BOWFEST (Bowhead Whale Feeding Ecology Study) projects, funded by the Minerals Management Service, as well as in the Passive Acoustic Monitoring in the High Arctic project, which is funded by the S&T and is part of NOAA's contribution to the International Polar Year.

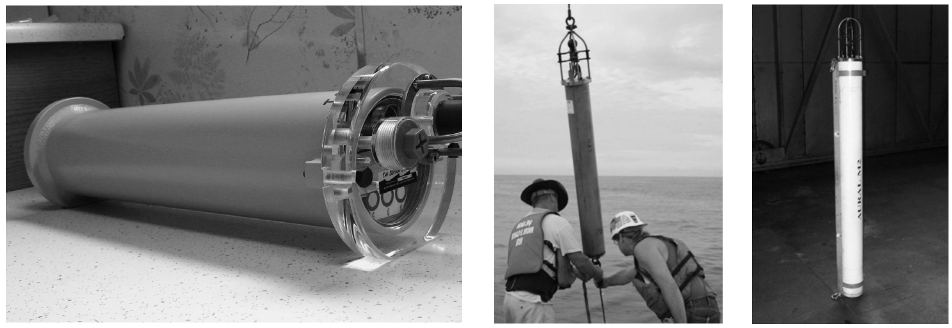


Figure 2. Autonomous passive acoustic recorders. From left to right: EAR, Haruphone, and AURAL. (Not to scale.)

ACOUSTICS ARSENAL

In all projects, bottom-moored passive acoustic recorders are being used to collect long-term recordings. Several types of recorders have been deployed (Fig. 2): EARs (ecological acoustic recorder in collaboration with Drs. Marc Lammers and Whitlow Au, Hawaii Institute of Marine Biology, University of Hawaii); Haruphones (Haru Matsumoto, CIMRS, Newport, Oregon); and AURALs (autonomous underwater recorder for acoustic listening; Multi-Électronique, Inc., Rimouski, Quebec, Canada). These recorders all have the same basic components: an underwater sensor (hydrophone) and a pressure housing containing the recording circuitry, batteries, and hard drives. They are all programmable to record on a user-chosen duty cycle and frequency range. The Haruphone and AURAL are substantially larger than the EAR unit (~6 ft vs. ~2 ft) and do not have a built in autodetector. The AURAL is the only recorder that can be purchased instead of rented, which is very cost-effective over the long term for these projects.

Sonobuoys were deployed only during the PRIEST project. These are free-floating expendable underwater listening devices created for military applications. Simple in concept, the underwater sensor picks up acoustic signals and sends them to a surface float where they are transmitted back to the ship (or aircraft) via VHF radio waves. Sonobuoys are very compatible with visual surveys in that they can be deployed and monitored while the vessel is under way. Monitoring distances (from the ship to the sonobuoy) are based on line-of-sight and battery strength of the sonobuoy but typically fall within the 10-15 mi range with the receiving antenna installed high on the vessel. Acoustic detection distances (from whale to sonobuoy) are highly dependent on underwater propagation conditions and so can vary widely among research areas. Sonobuoys come in two main types: omnidirectional sonobuoys, which can record frequencies up to 20 kHz and transmit just the acoustic signal; and DiFAR (directional fixing and ranging) sonobuoys, which have a limited frequency bandwidth (<2.5 kHz), but which transmit both the acoustic signal and bearing information of the sound source from the buoy. Cross-bearings calculated from two or more sonobuoys allow for real-time whale localizations. Sonobuoys have a limited shelf life, and the military sends them to surplus after they reach their expiration date. Because new sonobuoys are budget-prohibitive and because our research can tolerate a much higher failure rate than the U.S. Navy's, most marine mammal scientists rely on donations of expired sonobuoys from the military.

PRIEST (PACIFIC RIGHT WHALE EVALUATION STUDY)

The PRIEST project is a multiyear study of the distribution, abundance, and habitat use of North Pacific right whales in the North Aleutian Basin and southeastern Bering Sea using aerial and vessel surveys. There are three separate acoustic components within the PRIEST effort (Fig. 3). Over 300 DiFAR sonobuoys were deployed throughout the entire 2008 field season to maintain 24 hr/day passive acoustic monitoring for right whale calls. Our estimated acoustic detection range was 5-10 mi during the cruise. Both right whale upsweep and gunshot calls were detected (Fig. 4).

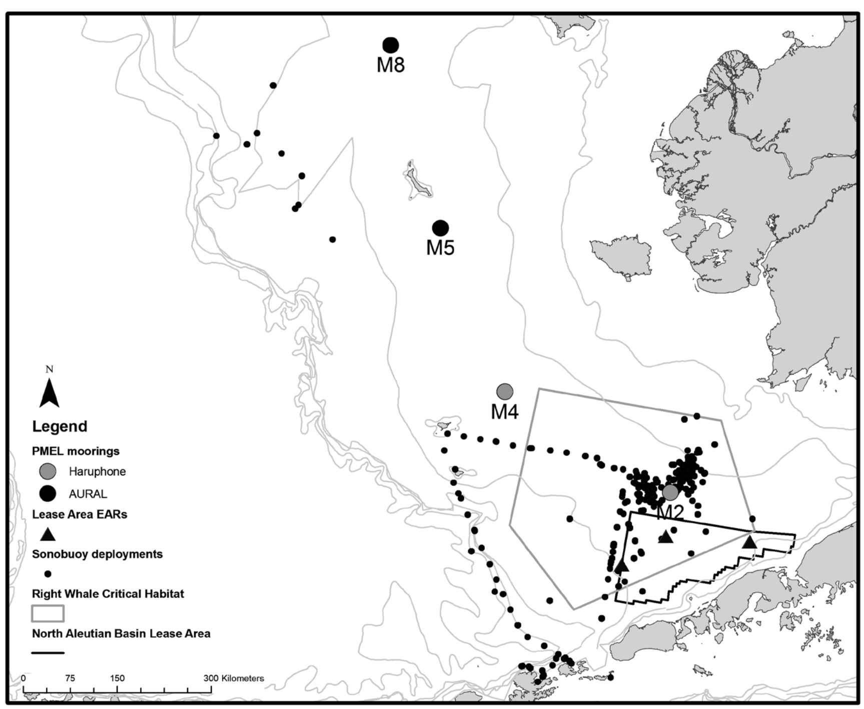


Figure 3. Passive acoustic monitoring effort in the Bering Sea, 2008.

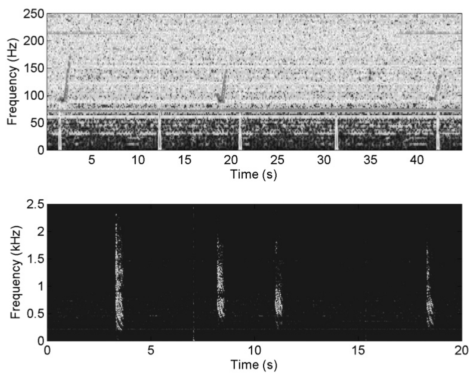


Figure 4. Spectrograms of right whale calls detected during the 2008 PRIEST cruise: (top) upsweeps; (bottom) gunshots.

The spatial distribution of the presence of these sounds on the sonobuoys is shown in Figure 5. If a call was detected, the acousticians could then direct the vessel to within sighting distance of the whale. In 2007, the sonobuoys used were over 30 years old and had a poor success rate. For this reason, we are extremely grateful to Jeff Leonard (Naval Surface Warfare Center, Crane Division) and Theresa Yost (Naval Operational Logistics Support Center) for providing 15 pallets of newer surplus DiFAR buoys, which performed remarkably well.

Three EAR recorders (recording up to 2 kHz on a 10% duty cycle for a year) were also deployed within the North Aleutian Basin Lease Area on PMEL-built subsurface moorings (Fig. 6) designed for use in heavily-trawled locations. Some of the highest costs associated with long-term acoustic recorder moorings, especially in the remote areas we need to monitor, are the moorings themselves and the ship-time required to transit to the mooring site and deploy the moorings. For this reason, we are fortunate to have the opportunity to occupy four moorings deployed by Phyllis Stabeno (PMEL/AFSC Ecosystems and Fisheries-Oceanography Coordinated Investigations (EcoFOCI)) in the Bering Sea. The M2 and M4 moorings have Haruphones (recording up to 1 kHz continuously for a year), while AURALs (recording up to 4 kHz on a 30% duty cycle for a year) have been included on the M5 and M8 moorings. These instruments extend acoustic monitoring initiated near M2 in October 2000.

BOWFEST (BOWHEAD WHALE FEEDING ECOLOGY STUDY)

The BOWFEST project is a multiyear study on the feeding ecology of bowhead whales in the western Beaufort Sea. Passive acoustic surveillance began in 2007 when six AURAL recorders were deployed in an arc off Barrow, Alaska (Fig. 7). Four of these recorders were moored along the 100-m isobath on PMEL-built subsurface moorings (Fig. 8), while the others were kindly piggybacked on two of Steve Okkonen's (University of Alaska–Fairbanks) shorter-term oceanographic moorings (Figs. 7, 9) in shallower water. One of Okkonen's moorings was retrieved at the end of the 2007 season; but, unfortunately, the other was lost. During the 2008 field season, Kate Stafford (APL–UW) retrieved the four off-shore moorings and redeployed them, along with the fifth AURAL and two of her own (National Oceanographic Partnership Program (NOPP)-funded) AURALs, to make two 3-unit arrays and one single mooring (Fig. 7). In addition, a pilot outreach study involving acoustic localization of bowhead whales, correlated with visual observations, was begun using four hand-deployable short-term PMEL-built EAR moorings (Fig. 7).

IPY (INTERNATIONAL POLAR YEAR)

Compared to the PRIEST and BOWFEST projects, our IPY project was relatively straightforward: AURAL recorders (recording up to 4 kHz on a 30% duty cycle for

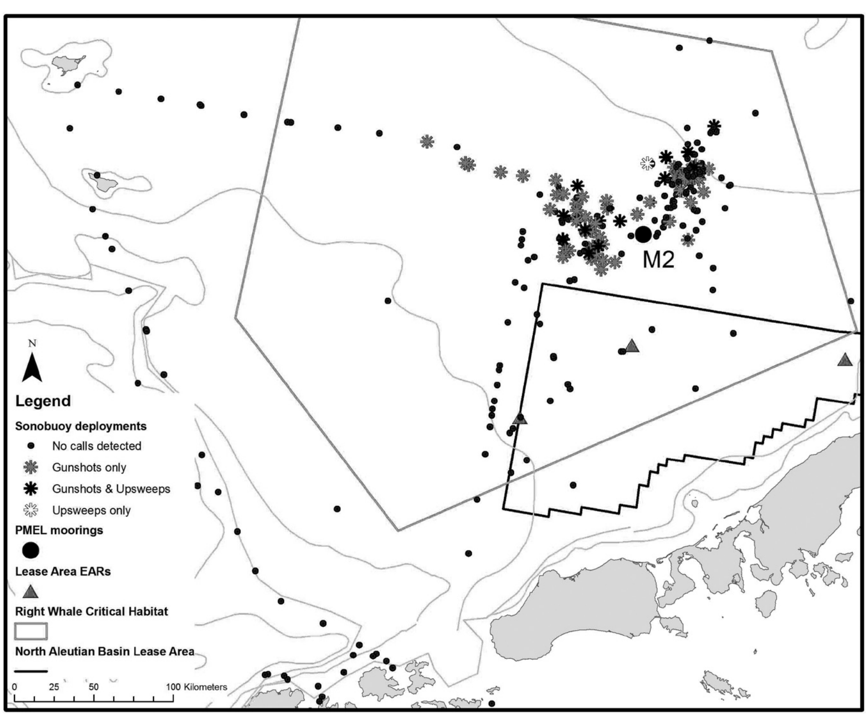


Figure 5. Presence or absence of right whale gunshot and/or upsweep calls on sonobuoys deployed during the 2008 field season.

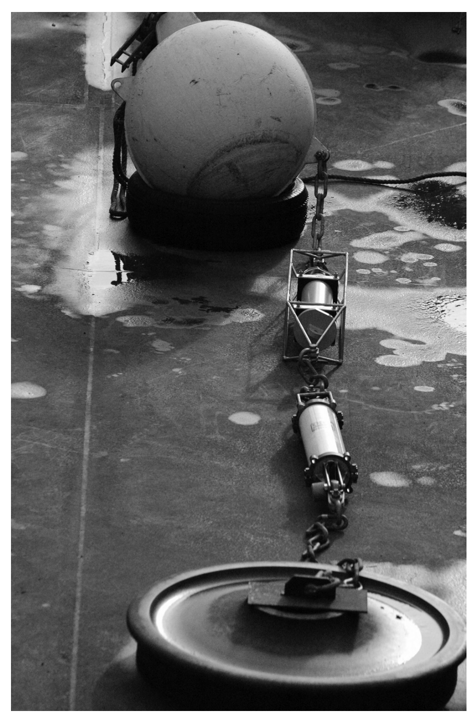


Figure 6. A North Aleutian Basin EAR mooring prior to deployment. Photo by Desray Reeb.

a year) were installed on subsurface oceanographic moorings in the Chukchi Sea, Fram Strait, and NW Svalbard by collaborating scientists Humfrey Melling (Institute of Ocean Sciences, Sidney, BC, Canada), Ursula Schauer and Dirk Kalmbach (Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany), and Oystein Wiig (Natural History Museum, University of Oslo, Oslo, Norway), respectively. Ultimately, acoustic data from these three recorders will be integrated with data obtained from recorders deployed by other researchers in the Alaskan and Canadian Beaufort Seas, providing a synoptic record of marine mammals and baseline ambient noise levels for roughly one-half of the Arctic continental shelf seas.

By Catherine Berchok

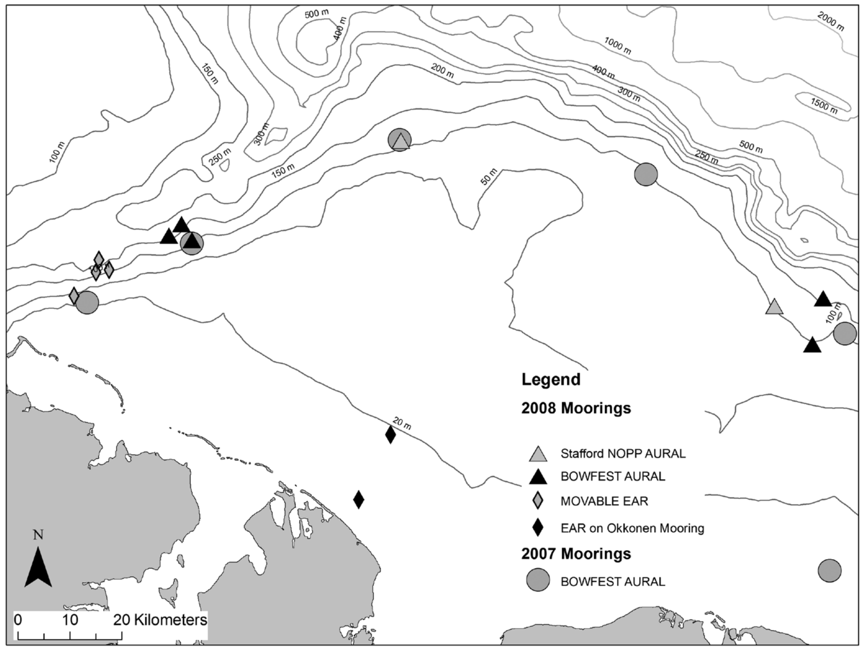


Figure 7. Passive acoustic monitoring effort in the western Beaufort Sea, 2007–2008.

POLAR ECOSYSTEMS PROGRAM

Review of Ribbon Seal Status

A Biological Review Team (BRT) composed of scientists from the AFSC and PMEL completed a review of the conservation status of ribbon seals (*Histriophoca fasciata*). The review was undertaken in response to a petition filed in December 2007 by the Center for Biological Diversity to list the ribbon seal as threatened or endangered under the U.S. Endangered Species Act (ESA), primarily due to concern about threats to this species' habitat from climate warming and loss of sea ice.

A primary task in an ESA status review is to conduct an extinction risk assessment to determine whether the petitioned species is threatened or endangered. To assess the extinction risk, the BRT evaluated the risks based on specific demographic factors of the species, such as abundance, productivity, spatial structure, and diversity, as well as specific threats faced by the species, as outlined in Section 4(a)(1) of the ESA:

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

Figure 8. AURAL mooring being deployed from the U.S. Coast Guard icebreaker *Healy* in 2008.

Foremost among the threats faced by the species is the potential destruction or modification of its sea-ice habitat from a warming climate, which is now widely acknowledged to be influenced by anthropogenic emissions of greenhouse gases. Evaluation of this threat required a detailed focus on the geographical and seasonal use of sea ice by ribbon seals, which are associated with the ice mainly for reproduction and molting during the spring in the Bering Sea and Sea of Okhotsk.

In contrast to the Arctic Ocean, where sea ice is present year-round, the ice in the Bering Sea and Sea of Okhotsk is seasonal in nature. An analysis of future sea-ice projections indicated that despite the recent dramatic reductions in Arctic Ocean ice extent during summer, the sea ice in the northern Bering Sea and Sea of Okhotsk is

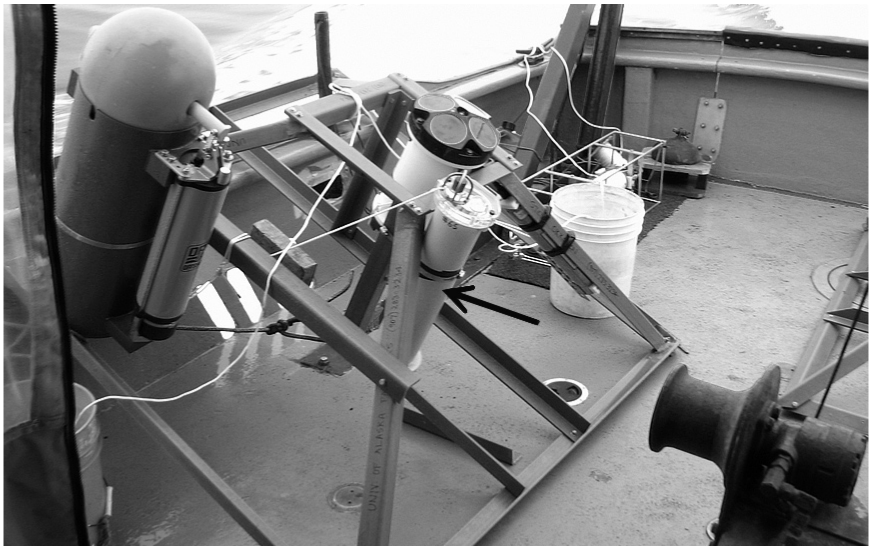


Figure 9. Okkonen (University of Alaska – Fairbanks) mooring frame deployed from the *Annika Marie* (EAR recorder indicated with arrow). Photo by Bob Campbell (University of Rhode Island).

expected to continue forming annually in winter for the foreseeable future (defined as the year 2050 for this assessment). The sea-ice regimes in these seas will continue to be subject to large interannual variations in extent and seasonal duration, as they have throughout recorded history. While there may be more frequent years in which ice coverage is reduced, the late March to early May period in which ribbon seal reproduction occurs will continue to have substantial ice, particularly in the northern regions of the breeding range. In years of low ice, it is likely that ribbon seals will adjust at least in part by shifting their breeding locations in response to the position of the ice edge—as they have likely done in the past in response to interannual variability.

There could be impacts on ribbon seal survival and recruitment from more frequent years of reduced ice thickness and duration of seasonal ice coverage. Decreased availability of stable platforms for adults to complete their molt out of the water may lower survival, but it is not currently possible to quantify this impact or the extent to which ribbon seals may adapt by shifting locations for the key life-history events of breeding and molting. Weaned pups are likely dependent on sea ice for a 2-3 week period as they develop self-sufficiency in foraging. They enter the water regularly during this period and, therefore, may not be particularly sensitive to modest reductions in coverage or quality. However, they may be relatively limited in their capability to respond to rapidly deteriorating ice fields by relocating over large distances, a factor that could occur more frequently in the foreseeable future.

In consideration of all of the identified threats, the assessment of the risks posed by those threats, the possible cumulative impacts, and the uncertainty associated with all of these, the BRT drew the following conclusions:

Ribbon seals are not in current danger of extinction throughout all or a significant portion of their range.

The ribbon seal population is likely to decline gradually for the foreseeable future, primarily from slight but chronic impacts on reproduction and survival caused by reduced frequency of years with sea ice of suitable extent, quality, and duration of persistence.

Despite the expectation of a gradual decline, ribbon seals are not likely to become an endangered species within the foreseeable future throughout all or a significant portion of their range.

The status review was published as a NOAA Technical Memorandum (http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-191.pdf) and was used to support a decision by NMFS that ribbon seals should not be listed as threatened or endangered at this time (http://www.fakr.noaa.gov/protectedresources/seals/ice.htm). However, in view of the possibility of a decline in the ribbon seal population, the species was added to the NMFS Species of Concern list (http://www.nmfs.noaa.gov/pr/species/concern).

By Peter Boveng

Resource Assessment & Conservation Engineering (RACE) Division

FISHERIES OCEANOGRAPHY COORDINATED INVESTIGATIONS (FOCI)

Recruitment Processes

Janet Duffy-Anderson attended the 7th International Flatfish Symposium convened in Sesimbra, Portugal, 1-9 November. She presented work describing the patterns of abundance and distribution of Alaska plaice (*Pleuronectes quadrituberculatus)* eggs, larvae (Fig. 1), and pelagic juveniles over the southeastern Bering Sea shelf. Results from the paper suggest that connectivity between spawning areas and nursery habitats is influenced by wind forcing. Climate-mediated changes to dispersal trajectory or timing is expected to have significant impacts on recruitment in this species, though entrainment in consistent, directional currents may modify these effects. Dr. Duffy-Anderson was invited to take a more active role in the future planning of symposia by this group.

Knut Vollset, a Ph.D. candidate at the University of Bergen, Norway, was a visiting scientist with the Recruitment Processes Program from 15 August 2008 to 15 February 2009. Knut is a student of Professor Arild Folkvord and studies environmental and behavioral factors that influence the distribution of early life stages of marine fishes, mainly herring and cod. In Seattle, Knut conducted experiments with Dr. Kevin Bailey on conditions influencing feeding rates of small marine fishes, using sticklebacks as a model predator. Knut also did a cooperative project with Dr. Paul Hershberger at the U.S. Fish and Wildlife Service's (USFWS) Western Fish Disease

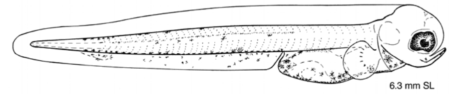


Figure 1. Larval Alaska plaice (*Pleuronectes quadrituberculatus).* Illustration by Beverly Vinter.

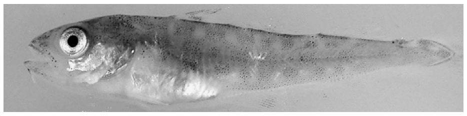


Figure 2. Juvenile Pacific cod *(Gadus macrocephalus*). Photo by Catherine Mecklenburg.

Laboratory on the effects of viral infections on herring's susceptibility to predators. In addition, Knut participated in an EcoFOCI cruise on the NOAA ship *Miller Freeman* led by Janet Duffy-Anderson 8-20 September 2008.

Thomas Hurst (Newport Laboratory) visited with several members of the Recruitment Processes Program, 15-18 December to obtain historical collections of Pacific cod larvae and juveniles (Fig. 2) from the EcoFOCI program for a North Pacific Research Board (NPRB)-funded project that uses otolith microchemistry to estimate the contribution of larvae from Gulf of Alaska stocks to the Bering Sea. Dr. Hurst brought with him an Oregon State University student and a visiting international student who worked with EcoFOCI scientists to identify and dissect early life history stages of Pacific cod from the Gulf of Alaska and Bering Sea.

Tiffany Vance gave an invited talk at the 3rd National Center for Atmospheric Research (NCAR) Community Workshop on Geographical Information Systems (GIS) in Weather, Climate and Impacts (27-29 October 2008) where she presented work on integrating the results of *in situ* data and models using GIS and visualizations. While visualization tools provide appealing pictures of complicated data, they can also be coupled with GIS to provide advanced analyses. New tools for the representation of multidimensional data allow users to visualize and interact with datasets such as three-dimensional output from particle tracking models or the paths of satellite-tracked drifters (Fig. 3). Analyses can include characterizations of the environment encountered by larvae and the delineation of essential habitats for pelagic larvae.

Dr Vance's talk "Moving beyond data visualization for just visual impact–coupling environmental models, particle tracking and spatial analyses using multidimensional GIS" focused on recent developments in interoperability, such as the direct ingestion of netCDF data in ArcGIS and the use of Java tools for data analysis, and how these developments enhance our ability to represent multidimensional data in GIS. Examples of applications to study the dispersion of rock sole larvae and the survival of walleye pollock larvae were presented (Fig. 4).

More information on the workshop is available on the web at http://www.gis.ucar.edu/08workshop/agenda.jsp.

By Ann Materese, Tiffany Vance, and Jeff Napp

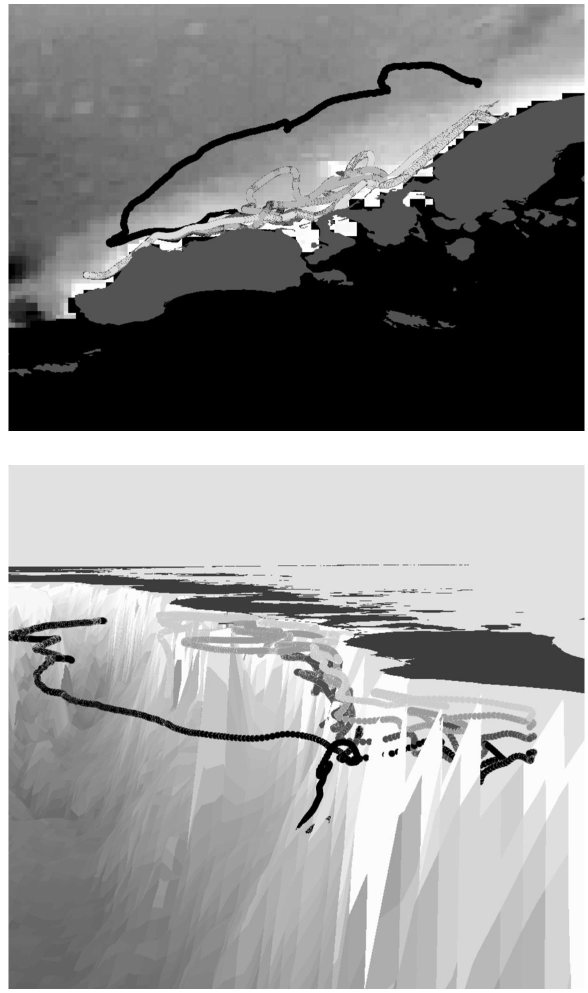


Figure 4. Map view (top) and oblique view (bottom) of the potential paths of rock sole larvae based upon running a particle tracking model on top of the ROMS circulation model. Data from Lanksbury et al. 2007.

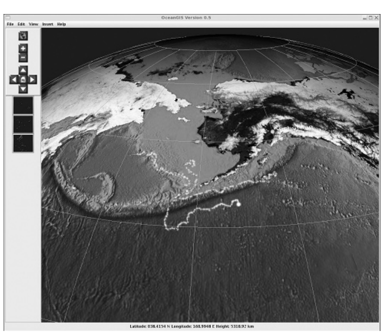


Figure 3. Path of satellite drifters released as part of EcoFOCI studies in the Gulf of Alaska and the Bering Sea. Drifter paths show currents that can affect the dispersion of larvae.

FISHERIES BEHAVIORAL ECOLOGY PROGRAM: NEWPORT LABORATORY

Sources of Growth Variability in Age-0 Northern Rock Sole

Considerable research effort has been directed at evaluating spatial and temporal patterns in growth rates of juvenile fishes and is often used to define "essential fish habitat," evaluate habitat quality at different sites, and indicate potential future recruitment. Furthermore, understanding the causes of contemporary variation in growth rates can offer insights into the likely consequences of climate change for growth and recruitment of coastal marine fishes.

In conjunction with the AFSC and Oregon State University colleagues, the Fisheries Behavioral Ecology Program (FBEP) examined patterns in growth variability in North Pacific Ocean and Bering Sea fishes through integration of field sampling, laboratory experiments, and modeling. Of particular interest was identifying the sources of environmental variability contributing to variable growth of larval and juvenile stages and quantifying their relative impacts.

In a recently completed study, Thomas Hurst and colleagues examined the abundance patterns and growth dynamics of age-0 northern rock sole (*Lepidopsetta polyxystra)* over 4 years (2004-07) in three Kodiak Island nursery areas (Holiday Beach in Middle Bay, Pillar Creek Cove in Monashka Bay, and Shakmanof Beach in Shakmanof Bay). Following the settlement period, fish were sampled monthly (July-October) with a 3-m beam trawl at

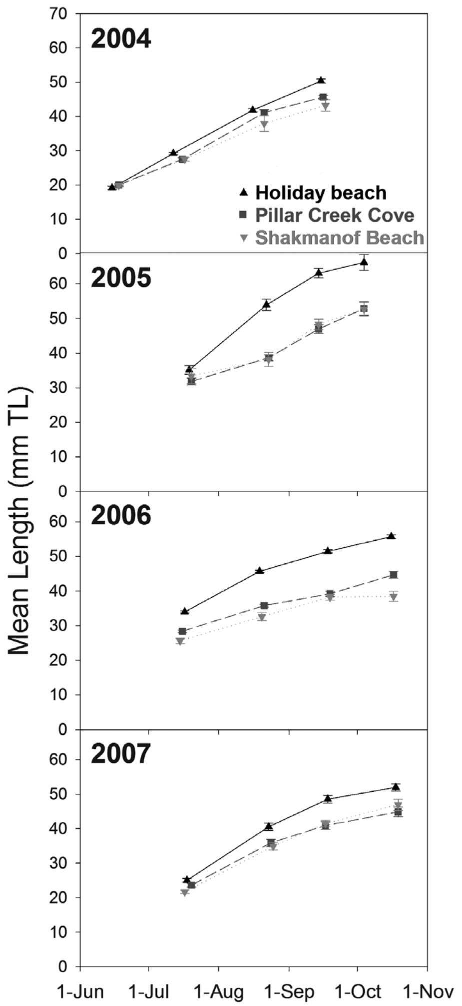


Figure 5. Growth rates of age-0 northern rock sole in three Kodiak Island embayments, 2004-2007. Symbols are mean length ± standard error of fish all fish in sample. Triangles–Holiday Beach; Squares – Pillar Creek Cove; Inverted triangles–Shakmanof Beach.

a series of fixed-position transects at each site. Growth rates of age-0 northern rock sole were based on observed increases in mean size between monthly sampling dates. Additionally, "Realized Growth" (RG) expressed the rate of observed growth in the field relative to maximum potential growth based on prevailing water temperatures. Temperature recorders were placed at each site to determine local spatial variation, and a long-term record was used to describe regional inter-annual variability and serve as a benchmark for site-specific comparisons. Site-specific temperature regimes were converted to potential growth rates based on previously established relationships.

The results of this study offer new insights into the role that temperature variation plays in the early life history of Gulf of Alaska northern rock sole. Average size of northern rock sole in mid-July (following the settlement period) ranged from 21.7 to 35.1 mm and was positively related to regional temperatures in the preceding winter and spring, suggesting that temperature may be regulating the timing of spawning and larval growth rates. Further, variation in size among sites was less than that observed among years, indicating the importance of regional pre-settlement conditions.

Summer growth on the nursery grounds varied significantly among sites and years, with average length of age-0 fish in mid-September ranging from 38.2 to 63.1 mm. Contrary to expectations of density-dependence and thermal regulation, nursery ground growth rates (expressed in mm·day^{-1} or RG) were not significantly correlated with fish density or water temperatures. Fish at the Holiday Beach site exhibited the highest growth rates in all 4 years of sampling (Fig. 5) despite the high inter-annual variance in fish density observed at this sight. Growth was generally slowest at the Shakmanof Beach site. While temperatures were slightly lower at this site, thermal differences were insufficient to account for growth differences.

Application of observed variation in single parameter perturbation models of growth was used to quantify the relative contributions of variation in post-settlement size, RG, and thermal regime to first-year growth. The minor contribution of thermal variation to summer growth rates appears related to the comparatively low thermal sensitivity of northern rock sole. Average temperature varied 2.0ºC among years, corresponding to a 10.3% increase in growth potential, or a cumulative potential increase of only 3.6 mm over the course of a 100-day growing season. Variation in realized growth rates varied systematically among years and sites and declined during the course of the growing season, possibly reflecting the conservative growth strategy of this cryptic species. Interestingly, the size variation observed following settlement in mid-July persisted through the growing season and accounted for over 50% of the body size variation observed by mid-September. These results suggest that climate changes influencing spawning time and larval growth may have larger impacts on first-year growth and recruitment of this species than temperature effects on the growth of nursery-resident juveniles.

Future work by FBEP researchers will examine patterns of prey availability and predator exposure to further refine biotic controls on fish growth. In addition, variability in fish condition and lipid content will be compared with growth rate patterns. Finally, the patterns observed at these sites will be contrasted with patterns in other parts of the species range.

by Thomas Hurst

SHELLFISH ASSESSMENT PROGRAM: KODIAK LABORATORY

Gulf of Alaska Small-mesh Trawl Survey, 2008

The annual small-mesh trawl survey for shrimp and forage fish again was conducted jointly by scientists from the AFSC's RACE Division and the Alaska Department of Fish and Game (ADF&G) Division of Commercial Fisheries (Fig. 6). The ADF&G research vessel *Resolution* was deployed for 129 tows in embayments around Kodiak Island and south of the Alaska Peninsula as far west as Pavlof Bay from 29 September to 24 October 2008. The 2008 effort marks the latest in a series that started in 1953.

As background, the *Resolution* has been used to conduct the survey since it was acquired by the ADF&G in 1971. Prior to 1971, only the AFSC was conducting the small-mesh trawl surveys and the original goal of this survey was to determine the potential for a commercial shrimp fishery in the Gulf of Alaska and Bering Sea. A major shrimp fishery did develop in the Gulf of Alaska during the 1970s, and at that point the ADF&G also began regular trawl surveys. With the subsequent decline of this fishery in the 1980s, survey efforts also declined; the RACE Division surveys were limited mainly to Pavlof Bay while ADF&G surveys covered the waters around Kodiak Island and the Alaska Peninsula triennially. Since 2001, ADF&G surveys have again been conducted annually and though they no longer conduct their own independent survey, since 2005 the RACE Division has provided support and has participated with the ADF&G in this survey. The ADF&G is responsible for survey design, providing the vessel platform, most personnel, data editing, and survey reports. It is now widely acknowledged that the span of the time series makes it one of the premier ecological data sets in the North Pacific.

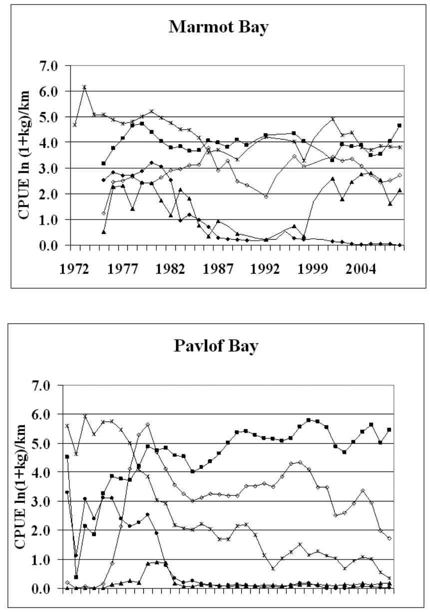
Both RACE Division and ADF&G staff are actively working to edit, update, and combine their time series databases. For example, the ADF&G is editing haul location information and also station areas to allow for comparable biomass calculations for the period of their time series. Scientists with the RACE Division are examining small-mesh survey data archives, including both the original deck logs and associated computer files that once resided on the now long retired Burroughs computer system but were subsequently "lost." Retrieval of these files has allowed us to compile a far more complete version of the time series than was previously available. The continual editing and updating of the databases present a challenge, however, to respond to requests for these comprehensive small-mesh data in a timely and accurate manner. Methodology and protocols must be developed across the two agencies (RACE SAP Oracle software-based and ADF&G Java software-based) which are needed to combine the databases and incorporate the latest corrections and updates, provide metadata, and also address the technology security concerns of each agency.

Since the survey was originally conducted primarily for shrimp stock assessment, minimal information was initially collected about other organisms in the remainder of the catch. Gradually more comprehensive information was recorded and has evolved to where the catch is currently identified to the species level for nearly all fish and invertebrates with catch weights and counts recorded for each taxa. Lengths are recorded from a representative sample of forage fish and commercially important groundfish and shrimp. Samples of shrimp are also preserved for sex determination and length measurement in the lab after the survey. Bottom temperatures are recorded with a sensor on the trawl headrope, and bathymetry and bottom hardness are recorded using both the Quester Tangent QTC4 and Simrad Olex systems. A photograph is taken of the catch from each haul as a visual record of the general catch composition.

The ancillary information collected on groundfish and other invertebrates, in combination with the shrimp data, is now viewed as being extremely valuable for the analysis of long-term changes in the marine community in the Gulf of Alaska. Community changes are commonly examined by tracking trends in relative abundance of selected taxa, as exemplified by the trends observed in Marmot and Pavlof Bays (Fig. 7). These two bays have been some of the most consistently surveyed since the small-mesh trawl net was standardized by NMFS in 1971; both bays also formerly supported major shrimp fisheries.

Both Marmot and Pavlof bays experienced a decline in shrimp and forage fish densities and a concurrent rise in Pacific cod following the well-documented climate regime shift in the late 1970s. Northern pink shrimp (*Pandalus borealis*) have continued to decline in Pavlof Bay throughout the last three decades, while in Marmot Bay the decline has not been as dramatic or long lasting. Shrimp populations in Marmot Bay have remained an important component in the catch and have actually shown some increases in density since 1990. In addition, eulachon (*Thaleichthys pacificus*) populations have rebounded in Marmot Bay, a trend not seen in Pavlof Bay. The reason for the differences in community structure between these bays in not clear but certainly warrants further investigation. Also of interest in the 2008 survey results was the widespread capture of ocean shrimp (*Pandalus jordani)* around Kodiak and also along the Alaska Peninsula as far west as the Shumagin Islands. *P. jordani* is a lower-latitude pandalid shrimp species that is commercially fished off British Columbia and the west coast of the United States. Although it has been sporadically caught in the small-mesh survey since 1974, more consistent catches starting with the 2004 survey may signal a northward distribution shift in response to recent warming in the Gulf of Alaska.

by Dan Urban and Brian O'Gorman



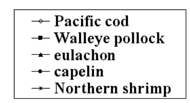


Figure 7. The catch per unit effort (CPUE as ln (x + 1) kg km^{-1}) of selected species from Marmot Bay (upper plot) on northeast Kodiak Island and Pavlof Bay (lower plot) on the western end of the Alaska Peninsula, 1972 to 2008.

Figure 6. Kurt Peterson and Aaren Ellsworth sort the shrimp catch during the 2008 small-mesh survey. Photo by Dave Jackson.

RESOURCE ECOLOGY & FISHERIES MANAGEMENT (REFM) DIVISION

RESOURCE ECOLOGY & ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

During the fourth quarter of 2008, fisheries observers collected 363 stomach samples from the eastern Bering Sea. During the Bering-Aleutian Salmon International Survey (BASIS) cruise, AFSC scientists analyzed 1,323 stomach samples at sea. In the laboratory, Resource Ecology & Ecosystem Modeling (REEM) Program staff analyzed 1,307 stomach samples from the eastern Bering Sea and 509 stomach samples from the Gulf of Alaska. In total, 1,106 records were added to the REEM food habits database.

By Troy Buckley, Geoff Lang, and Mei-Sun Yang

Ecosystem Indicators

REEM staff completed the Ecosystem Considerations appendix to the stock assessment and fisheries evaluation (SAFE) report to the North Pacific Fisheries Management Council (NPFMC) and presented the appendix to the NPFMC Bering Sea/Aleutian Islands and Gulf of Alaska Plan Teams, the Scientific and Statistical Committee, and the Advisory Panel. For this year's report, updates were made to 43 indicators, and four new contributions (on Arctic sea ice, groundfish condition, Gulf of Alaska lingcod bycatch, and Gulf of Alaska continuous plankton recorder data) were added. In addition, as a step towards developing integrated ecosystem assessments (IEAs) for the region, an ecosystem assessment was included following the Driver–Pressure–State–Impact–Response (DPSIR) model. As part of this effort, indicator trends were summarized in a graphical format, and combined indicators by species group were added (Fig. 1). This represents a substantial improvement in the form and format of the Ecosystem Assessment.

By Kerim Aydin and Jennifer Boldt

Ecosystem Modeling and Resource Ecology

Three REEM Program members gave presentations and co-chaired working groups at the first annual principal investigators' meeting of the North Pacific Research Board's Bering Sea Integrated Research Program (BSIERP). This program is a 5-year, $51 million collaboration between the North Pacific Research Board and the National Science Foundation, with more than 90 investigators examining the present and potential future of the Bering Sea ecosystem. REEM Program researchers are coordinating and developing the major modeling effort of BSIERP, studying the functional responses between groundfish predators and prey and performing associated field work. BSIERP is unique in that it aims to bring modelers and field researchers together at all stages of the project. REEM modelers presented their models at the meeting in order to receive feedback from meeting participants and participated in multiple working groups aimed at synthesizing the scientific results of the BSIERP effort.

By Kerim Aydin, Troy Buckley, and Ivonne Ortiz

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Preliminary Alaska Fishery CGE Model Developed

After completing a supply-determined social accounting matrix (SDSAM) model, an import-ridden social accounting matrix (SAM) was prepared to develop an Alaska fishery computable general equilibrium (CGE) model. The development of the

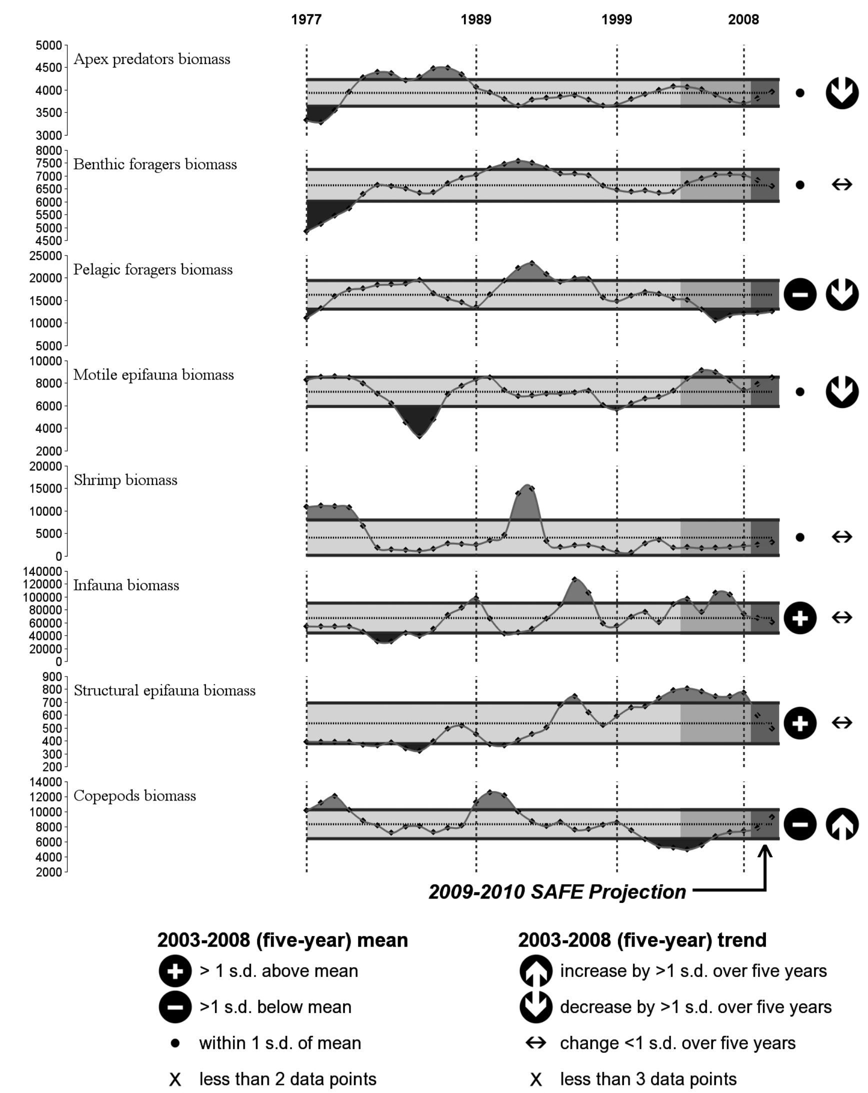


Figure 1. Time trends of biomass of major guilds (species groups) for the past 30 years in the eastern Bering Sea, from the Ecosystem Considerations chapter of the North Pacific Fishery Management Council stock assessment and fisheries evaluation report for 2009. Light shaded area shows ± 1 standard deviation (s.d.) of the time series for the measured time period.

CGE model was a result of dissatisfaction with fixed-price models such as input-output (IO) and SAM models. The fixed-price models have several important limitations. In these models, prices are assumed to be fixed, and no substitution is allowed between factors in production or commodities in consumption. As a result, in cases where the fixed-price assumption may not be realistic, these models tend to overestimate impacts. CGE models overcome these limitations. In CGE models, prices are allowed to vary, triggering substitution effects in production and consumption. The CGE models, therefore, enable analysts to easily examine the economic welfare implications of a policy change. Furthermore, the CGE approach is generally more appropriate than other regional economic models for analyzing the impacts of a change in productive capacity of resource-based industries. In the Alaska CGE model, both the "use" and "make" matrices are specified in the model. Therefore, a harvesting sector produces multiple commodities (i.e., species). The model has 22 industries, 8 of which are harvesting and processing industries, and 28 commodities. Currently, the model is being refined. Once the final version of the model is prepared, it will be used to simulate the distribution and magnitude of economic impacts associated with harvesting, processing, and support activities related to Alaska fisheries.

By Chang Seung and Edward Waters

BSAI Crab Economic Data Quality Review

As directed by NPFMC motions from February 2003 and December 2006, a rigorous set of procedures for assessing and documenting data quality of the Bering Sea and Aleutian Islands (BSAI) Crab Economic Data Report (EDR) database have been developed and implemented by the Economics & Social Sciences Research (ESSR) Program staff and contractors. Results of third party validation audits and extensive submitter feedback and data quality reviews have been documented in the form of a detailed metadata document, along with numerous database details intended to ensure long-term integrity of the database and access by data users.

Following presentation of the draft metadata document to the Council in February 2008 by ESSR Program staff, the Council issued a motion directing the Pacific Northwest Crab Industry Advisory Committee (PNCIAC) to participate in a formal review of EDR data quality and the metadata document. Preliminary results of the PNCIAC review were presented by ESSR staff at the October Council meeting in conjunction with the 3-year review of the crab rationalization program. The Council's Scientific and Statistical Committee (SSC) recommended completion of the data quality review and incorporation of EDR data into analysis of the impacts of rationalization. ESSR staff worked intensively with PNCIAC and Council staff during the October-December period and presented the completed analysis at the December Council meeting. The principal outcome of the data quality review was a system for classifying EDR data elements according to data quality and suitability for use in analysis and decision support. Data elements were ranked as: A) high quality and suitable for analysis, B) data quality-limited but suitable for analysis with appropriate adjustments and interpretation; or C) not reliable for analysis. Approximately one-third of the EDR data elements fell into each category. The data quality analysis efforts will be used beginning 2nd Quarter, FY 2009 as the foundation for substantial revision of the crab EDR program and to improve other economic data collection initiatives.

By Brian Garber-Yonts

Global Economic Model Used to Analyze International Trade in Food and Energy Commodities Under IPCC Scenarios

Researchers affiliated with the Population Climate Change (PCC) Program at the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, recently completed an analysis of economic data from the Global Trade Analysis Project (GTAP), a comprehensive source of production and consumption data with bilateral trade information for 50 sectors and over 40 countries plus other regions that cover the world. A rigorous energy-balancing procedure, developed by the U.S. Department of Energy (DOE), was applied to data from GTAP that reconciled its input-output (IO) accounts with energy statistics from the International Energy Agency (IEA) by computing energy-prices measured in physical units of energy (e.g., U.S.$/Joule). Energy prices for each country and region were combined with values from the Intergovernmental Panel on Climate Change (IPCC) that represent the energy content of various fossil-fuels (e.g., oil, natural gas, and coal) to derive emissions coefficients (in tons of carbon, tC) for each dollar of production or consumption in each.

The ESSR Program's global economic model, the Population-Environment-Technology (PET) model, was calibrated to these energy-balanced GTAP data to form a model benchmark or initial condition. Some words on the structure and origins of the PET model are in order. The model was developed at Stanford University and California State University Monterey Bay, with support from DOE and the U.S. Environmental Protection Agency (EPA). It is based on a standard dynamic computable general equilibrium model that assumes forward-looking behavior drives household savings and consumption decisions, i.e., endogenously through dynamic optimization. In addition, the PET model has a multi-dynastic representation of household age, size, urban/rural status, and other demographic characteristics. Furthermore, it utilizes a set of flexible production functions that can simulate any factor or input specific type of technical change. For example, labor-augmenting technical change expands the scale of the economy in a uniform way under most conditions such that energy demand increases in proportion to the total size of the economy, while energy-saving technical change reduces the amount of energy used in production per unit of output (i.e., energy-intensity). Parameters in the PET model for labor-augmenting and energy-saving technical change were tuned such that model output for per capita GDP and total carbon emissions matched scenarios from the IPCC Special Report on Emissions Scenarios (SRES), updated for the period 2000-2100 by the Greenhouse Gas Initiative Program at IIASA. A preliminary set of results from the PET model was used to examine the sensitivity of SRES scenarios to alternative baseline population paths (low, medium, and high) that are plausible under each.

Current work on the PET model is expanding the number of regions and disaggregating trade in food commodities, including fish, among Pacific Rim countries and adding data from national household surveys on consumption patterns, stratified by demographic factors such as age and household size. New results and analyses, including policy simulations of atmospheric carbon stabilization scenarios, are expected through 2009. In related work, supported by a DOE grant to the University of Illinois at Urbana-Champaign (UIUC), the PET model and energy-balanced GTAP data will be coupled with a global biogeochemical cycles (GBC) model of moderate complexity to produce land-use and climate scenarios for the next century. The AFSC Ocean Acidification Research Plan proposes to extend these scenarios to use as boundary conditions for experiments and impacts in a crab bioeconomic model which is under development in the ESSR Program. Another project, which is pending final approval from NOAA, will develop an energy-balancing procedure to map output from the REEM Program's ecosystem models for the Gulf of Alaska and the Bering Sea to a standard system of demand equations from microeconomics that can be represented as a set of benchmark conditions in the PET model. The ultimate goal is to provide an analytical framework for REFM researchers to formally link results from ecosystem and economic models in IPCC scenarios.

By Michael Dalton

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

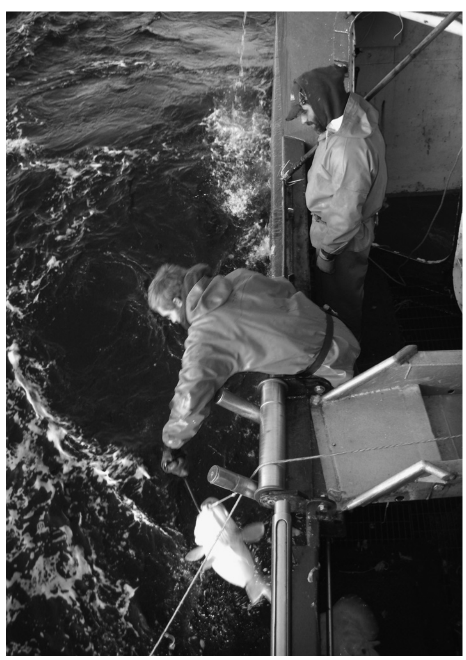
Tagging Pacific Cod Caught by Longlining: A Feasibility Cruise

A research cruise was conducted by the Status of Stocks and Multispecies Assessment (SSMA) Program's Fisheries Interaction Team (FIT) in fall 2008 to determine the best methods for handling longline caught Pacific cod in mark-recapture studies. The cruise was conducted aboard a vessel of opportunity, the fishing vessel (F/V) *Alaska Mist*, made possible by cooperation with members of the fishing industry and utilizing Cooperative Research Funds. Resulting data permitted confirmation of feasibility and refinement of plans for an extensive mark-recapture experiment scheduled for fall and winter 2009 and 2010.

Movement of Pacific cod has been observed qualitatively in the course of several studies conducted by the AFSC and the ADF&G. As stock assessments have become more sophisticated, there has been a growing need for better understanding of the movements of cod. To that end, the FIT mark-recapture experiment in fall/winter 2009 and 2010 is designed to estimate movement rates of Pacific cod among strata in the eastern Bering Sea. The study work will be cofunded by the North Pacific Research Board (NPRB) and the AFSC. Two research cruises are planned aboard a factory longliner, with a portion of the catch tagged and released and the remainder of the catch serving as compensation to the chartered vessel.

Cod caught by longline have been successfully tagged and released elsewhere in the world, but because FIT lacks expertise in this particular fishing method, a feasibility cruise was necessary to determine the best methods of removing fish from the longline, develop preliminary estimates of acute tagging mortality associated with fish removal methods, estimate expected sample sizes, and acquire expertise for collecting and interpreting longline CPUE data.

From 16 September through 8 October 2008, FIT scientist Peter Munro accompanied the *Alaska Mist* on a commercial longlining trip to catch Pacific cod in the eastern Bering Sea. The *Alaska Mist* is a 174-foot factory longliner, running an automatic longline system at 42,000-60,000 hooks per day, and processing the catch into headed and gutted frozen blocks. Two live tanks were installed on the vessel and the vessel provided untreated seawater. The cruise ranged widely, from east of St. George Island to 100 nmi to the west of Zhemchug Canyon. The majority of fishing occurred in the latter region at depths of 100-160 m. The vessel generously allowed cod to be taken from the line for research, and the captain and crew worked closely with the AFSC scientist to work out the best way to get the cod from the longline.



A Pacific cod being gaffed aboard the longliner F/V *Alaska Mis*t. Perspective is looking aft at the hauling station on starboard side from one deck up.

During the first week of the cruise, the vast majority of cod died, no matter what method was used to remove them from the line. Considerable time was spent making sure chlorine did not enter the water supply to the live tanks, evaluating differences between surface and bottom temperatures, and trying to control such factors as hauling speed. For several days we cooled the live tanks with ice made in the freezer hold and then gradually raised the temperature by slowly trickling in surface seawater. These efforts made no difference, other than to slow down the cod selection and tagging process even further. In consultation with colleagues in Norway and Scotland, we bled off the gas that inflated the body cavity consequent to embolism; however, there was no increase in survival rates.

Most of the fish could not survive the trauma due to stress while on the hook at the bottom and to gas embolism as the swim bladder ruptured on the way to the surface. A few cod did live however, and by the end of the first week of fishing, we had 19 survivors holding in the live tanks and increasing in vigor. This is a very small number, however, and boded ill for the future mark-recapture experiment in which we had hoped to be able to tag and release 100-200 cod per fishing day. One benefit of the first week of the feasibility study was determining the gentlest method of taking cod from the longline, and the crew working the roller became practiced at doing so without slowing down operations.

The second week of the cruise was devoted to close observation of cod as they died. Special note was made of characteristics of the small number that survived. Attention switched from how to remove the cod from the line to developing criteria for quickly identifying those likely to survive capture. It became apparent that selected cod died very quickly and, for the sake of observing the process, larger numbers of cod were selected from the longline, necessarily at a quicker selection rate. Eventually two critical observations were made. First,

Shelter deck of the F/V *Alaska Mist*, looking aft. Live tanks are on port side, just forward of the wheelhouse and quarters. The hauling station is directly to starboard of the tanks and one deck down. The weather shown here typified one day of the trip. In normal weather, whitecaps commonly formed in the surfaces of the tanks whenever the lids were raised for inspecting the cod held there.

cod had been selected for observation in batches during the first week but were selected in a stream of individuals during the second week. Second, those that survived, for the most part, could be identified within 30-60 seconds of entering the live tank. Observation in batches placed severe limitation on the total number of cod that could be examined by a single scientist. Once this was recognized, the apparent low survival rate posed fewer difficulties if a large enough number of cod could be examined. The short time required to identify survivors combined with the constant streaming of cod aboard by the longline meant that a large number of cod could indeed be examined for tag and release candidacy.

The third week of the cruise was spent collecting data under the new survivor identification criteria and estimating the probability of surviving capture for 24 hours or more. The probability of surviving for an hour or more following capture (initial survival) was 0.18. The probability of surviving 24 hours following selection for tag and release candidacy was 0.78 or greater (this is a conservative estimate since some data were included that were intended for estimating the initial survival rate). No mortality occurred for any cod that survived beyond 24 hours. In fact, the population in one live tank grew to 25 and remained at that level for 4 days. During that time we expected crowding and longer exposure to the presumably adverse conditions of the tank to reduce health and cause mortalities. Instead, the cod appeared to increase in vigor as they recovered from the barotrauma of capture.

These results lead us to expect to tag 100 or more cod per fishing day during the large-scale experiment scheduled for fall and winter of 2009 and 2010. This expectation is based on two assumptions: 1) that the observed initial survival rate holds and 2) that we can examine one fish every 60 seconds over a period of 10 hours of retrieval. This examination rate is conservative, both in the period of haul back and in the number of fish that can be examined. Furthermore, the large number of cod that can be safely held in a live tank will permit large sample sizes in estimating acute tagging mortality in the course of the mark-recapture experiment. The design for that experiment includes holding tagged cod in live tanks for 24, 48, and 72 hours and observing the mortality rate directly.

By Peter Munro

Groundfish Stock Assessments for 2009: Fishery Quota Recommendations

The Alaska groundfish management system is based on extensive data available from the AFSC's North Pacific Groundfish Observer Program and dedicated research cruises. Catch of target and prohibited species (e.g., Pacific salmon, crab, herring, and Pacific halibut) are estimated at sea or in processing plants to provide real-time information to ensure that fisheries do not exceed total allowable catches (TACs) or violate other fishery restrictions, such as time-area closures. Dedicated research cruises coupled with observer data make it possible to build detailed population dynamics models. Results from these modeling activities are used to determine the status of individual species and make recommendations for future catch levels.

Establishing TACs involves annual evaluation of the best available scientific information through a series of documents and public meetings. The first step begins with the preparation of stock assessment and fishery evaluation (SAFE) reports. These reports contain analyses summarizing the information about the individual stocks and species groups, and include acceptable biological catch (ABC) and overfishing level (OFL) recommendations for future years. The authors of these reports (generally NMFS scientists) present their findings to the North Pacific Fishery Management Council's (NPFMC) groundfish plan teams in September and November. At these meetings, the reports are reviewed, and recommendations for ABC levels are compiled into two SAFE report volumes (one each for the Bering Sea/Aleutian Islands (BSAI) and Gulf of Alaska (GOA) regions), along with Plan Team recommendations for ABC. The compiled reports are then submitted to the NPFMC Scientific and Statistical Committee (SSC) for further review. The SSC makes the final ABC recommendation to the Council, and the Council's Advisory Panel of industry representatives makes TAC recommendations. 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

Observer John Rand monitoring catch coming aboard at the F/V *Alaska Mist* hauling station. Perspective is from wheelhouse, looking forward.

than 2 million metric tons (t)) are met. The following rule applies for all federally managed groundfish species in a given year:

Catch < TAC < ABC < OFL

In practice, catch is often much less than TAC, and TAC is often much less than ABC. The multispecies management system is, therefore, based on the premise that no individual components are overfished or below stock sizes that are considered detrimental to the ecosystem. The most recent stock assessments can be obtained on the AFSC website at http://www.afsc.noaa.gov/refm/stocks/assessments.htm.

The Midwater Assessment Conservation Engineering (MACE) Program of the Center's RACE Division conducted two major surveys in 2008: the winter echo-integration trawl survey in the Shelikof Strait and nearby areas and the entire shelf region of the eastern Bering Sea (EBS) (with extensions into the Russian exclusive economic zone (EEZ)) to assess the summer abundance of walleye pollock and other species. Scientists from the AFSC's Auke Bay Laboratories (ABL) conducted the annual longline survey, which is designed primarily for sablefish but also produces data used in the Greenland turbot and some rockfish assessments. This survey covers the slope regions of the GOA along with segments of the BSAI regions. The groundfish assessment group also conducted the standard summer-trawl survey for the EBS shelf area and a separate EBS slope-region survey. Groundfish bottom-trawl surveys for the GOA are presently on a biennial cycle with the next one planned for summer 2009.

The Ecosystem Considerations chapter was updated, and the 236 page document details an overall picture of the ecosystem status with the following highlights:

- No groundfish stocks are overfished or approaching an overfished condition;
- No systematic decline in the amount of large fish from 1982 to 2006 was identified in community size spectrum analysis of the EBS;
- Recent exploitation rates on biological guilds are within one standard deviation of long-term mean levels;
- Discards and discard rates are below those prior to 1998;
- Five new closures were implemented in 2008 as part of protection for essential fish habitat, which encompass a large part of the northern Bering Sea (almost 50% of the U.S. EEZ off Alaska is now closed to bottom trawling);
- Despite warming trends throughout the Arctic, Bering Sea climate will remain controlled by large multiannual natural variability;
- In the Bering Sea, there is a return to below average groundfish recruitment from 2004.

Presently, projections of 2009 spawning biomass for the main groundfish stocks are estimated to be near or above their target stock size (B_{msy}), while the 2008 catch levels were below F_{msy} levels for both the BSAI and GOA regions (Figs. 2 and 3). Fisheries for these groundfish species during 2007 landed 1.9 million t valued at approximately $2.0 billion after primary processing. This harvest 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 pollock, which declined in 2008 from previous years but totaled about 1.0 million t. Many of the flatfish stocks (e.g., rock sole, Alaska plaice, and arrowtooth flounder) are at high levels, but catches remain 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 (Fig. 4). Rockfish species comprise 5%-8% of the groundfish complex biomass and are generally increasing based on recent surveys. Below are summaries of stock assessment results by area and species or species group.

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 walleye 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 2009 is 509,515 t, which represents a 5% decrease from the 2008 total. The largest contributor to this decrease was due to declines in Pacific cod and pollock. See Table 1.

Sablefish also declined by about 1,600 t (-12%). ABC levels increased in deep water flatfish (3%) and flathead sole (4%). Arrowtooth flounder was down by 2% (about 5,000 t). The ABC level increased slightly for Pacific ocean perch (112 t or 2%). The ABC for northern rockfish declined by 187 t (-4%) while the demersal shelf rockfish ABC dropped by 5% and pelagic shelf rockfish dropped by 9%. All other species groups ABC levels stayed the same, since new survey data were unavailable.

The abundances of Dover sole, flathead sole, arrowtooth flounder, Pacific ocean perch, rougheye rockfish, northern rockfish, and dusky rockfish are above target stock size. The abundances of pollock, Pacific cod, and sablefish are below target stock size. The target biomass levels for other deepwater flatfish, shallow-water flatfish, rex sole, shortraker rockfish, demersal shelf rockfish, other pelagic shelf rockfish, other slope rockfish, thornyhead rockfish, Atka mackerel, skates, sculpins, squid, octopus, and sharks are unknown.

For most stocks, the Council established TACs equal to ABCs with some exceptions. These exceptions include Pacific cod, where 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 (W) and Central (C) GOA), flathead sole (W and C 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 each 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* (DY), which obtained an DY/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 Alaska Department of Fish & Game (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 *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 short-term outlooks indicate that the stock should increase, added conservation measures were made in recommending an ABC level for GOA pollock.

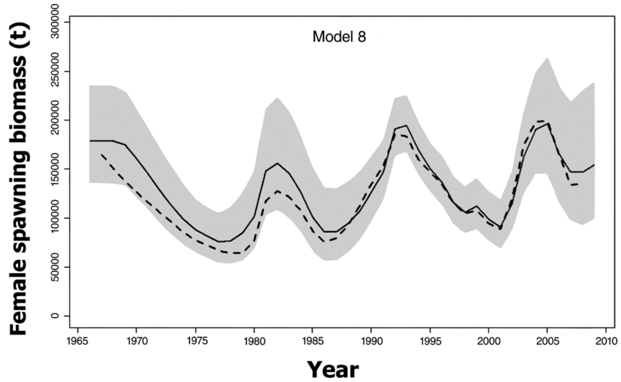


Figure 4. Estimated female spawning biomass from the current assessment (solid line) and approximate 95% confidence bounds compared to the female spawning biomass estimates from the 2007 assessment (dashed line) for BSAI Atka mackerel.

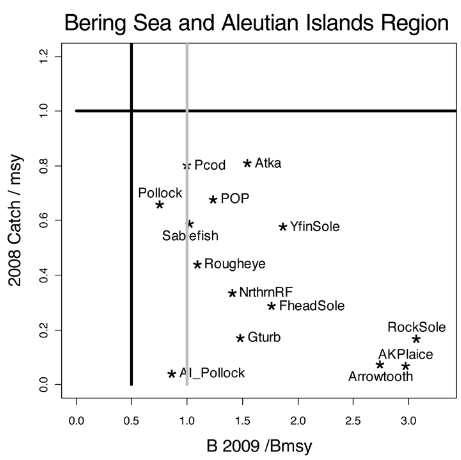


Figure 2. Relative 2009 spawning stock size compared to B_{msy} (taken to be $B_{35\%}$ for all species except EBS pollock) versus relative 2008 catch levels compared to 2008 F_{msy} levels for BSAI stocks.

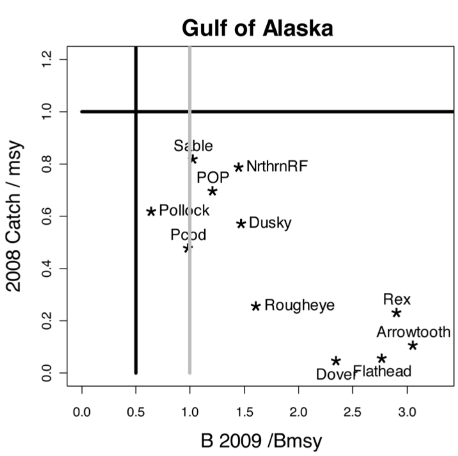


Figure 3. Relative 2009 spawning stock size compared to B_{msy} (taken to be $B_{35\%}$ for GOA stocks) versus relative 2008 catch levels compared to 2008 F_{msy} levels for GOA stocks. Note that Pacific cod stock status is based on previous assessment results.

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 decreased 2% from 2007 to 2008, a change which follows a 14% decrease from 2006 to 2007. The fishery abundance index was up 5% from 2006 to 2007. The spawning biomass was projected to be similar from 2008 to 2009, but is expected to decline through 2012. The projected 2009 spawning biomass is 36% of unfished biomass with the 1997 year class representing an important but waning contributor to the population. The projected spawning biomass (combined areas) for 2009 is 103,127 t (90% of $B_{40\%}$). Highlights of issues for sablefish include the impact of sperm whale depredation on the longline survey and the fact that an external stock assessment review is planned for 2009. The Alaska-wide recommended 2009 ABC is 16,080 t, approximately 11% lower than the 2008 level. Based on survey data, the relative decline is greater in the GOA than for the BSAI region, and this affects the spatial allocation of the available quota.

GOA Other Species: The other species complex in the GOA contains the following species groups: sculpins, squids, sharks, and

Table 1. The 2008 catch levels compared to the 2008 and 2009 ABC specifications and change in ABC (in metric tons (t)) for the groundfish species types for the Gulf of Alaska. Note that "Other species" ABC were specified for the first time starting in 2009 (change in ABC is based on all species groups except "Other species."

		ABC			
Species	2008 Catch	2008	2009	Change	
Pollock	51,721	60,180	49,900	down 10,280	-17%
Pacific Cod	42,424	66,493	55,300	down 11,193	-17%
Sablefish	12,284	12,730	11,160	down 1,570	-12%
Flatfish	15,544	123,759	125,617	up 1,858	2%
Arrowtooth flounder	29,163	226,470	221,512	down 4,958	-2%
Rockfish	22,816	33,548	33,005	down 543	-2%
Atka mackerel	2,071	4,700	4,700	same	0%
Skates	3,548	8,321	8,321	same	0%
Other species			6,540		
Total	179,571	536,201	516,055		-5%

octopus. In the past, assessments for these species in the GOA were done periodically, since ABCs and OFLs were not specified and the assessments were provided as appendices to the SAFE report. The TAC calculation for other species (previously TAC = 5% of the sum of target TACs) was modified in 2005 such that the Council may recommend a TAC at or below 5% of the sum of the target species TACs during the annual specifications process. Amendment 79 to the GOA FMP provides for the specification of ABC and OFL for the other species complex. This year full assessments were presented in the SAFE report to be used for the setting of harvest specifications for the other species complex, which are the sums of the ABCs and OFLs of the individual species groups. The recommended 2009 ABC for this group is 6,540 t.

BERING SEA/ALEUTIAN ISLANDS

The sum of the ABCs for 2009, as recommended by the Scientific and Statistical Committee, is just over about 2.4 million t, about 10% lower than the sum of the 2008 ABC values. This drop was driven by the reduction in ABC from EBS pollock (1.0 million t in 2008 compared to 815,000 t in 2009). Brief summaries of each BSAI species or species group follows.

EBS Pollock: Analyses of survey and fishery data show a decline in the walleye pollock biomass, which has resulted in the Council recommending a cut to the EBS pollock catch limit for 2009. The EBS pollock biomass was above average in the 1990s and apparently peaked in 2003, but the decline since then has contributed to lower catch limits for 2009. Walleye pollock in the EBS typically have been monitored with regular annual bottom trawl and biennial acoustic surveys. The 2008 effort, however, marked the third consecutive year that both surveys were conducted. The results of the 2008 bottom trawl survey suggested pollock abundance was in line with previous analyses, but the acoustic survey showed lower levels of abundance than expected. Combining these results and recent fishery observer information in an integrated analysis indicate a lower catch limit of 815,000 t for 2009, an 18.5% reduction from the 2008 catch level. The Council reviewed and discussed the assessment prepared at its December meeting and agreed with the need for lower pollock catch limits for 2009. Although the assessment indicates that the pollock biomass is low, there is some optimism about the future of the stock. The prognosis for 2010 is for improved stock levels because the 2006 year class appears to be above-average. The 2009 surveys will play a critical role in monitoring and in subsequent management decisions. While survey data plays a critical role in advising fisheries management, by autumn 2010 the fieldwork portion of the Bering Sea Integrated Research Program (BSIERP) will have been completed. This project will help to tie environmental and ecosystem data more fully into fishery management practices.

AI Pollock: In summer 2008 a panel of three experts outside of NMFS was convened to review the assessment approaches used for AI Atka mackerel and pollock. 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 were incorporated into the assessments for the December analyses. Relative to last year's assessment, the numerous revisions to this year's model resulted in a major change in the estimated trajectory of the stock relative to biomass reference points. In last year's assessment, the stock was estimated to have been well above $B_{40\%}$ for the entire time series. In contrast, this year's assessment estimates that spawning biomass to be about 75% of the $B_{40\%}$ level. The slight increases in spawning biomass since 1999 have resulted more from a decrease in harvest rather than from good recruitment. However, it should be noted that the average recruitment for this stock is estimated to be almost twice the median level. Spawning biomass for 2009 is projected to be 85,500 t.

BSAI Pacific Cod: The assessment authors evaluated a large array of model configurations and presented these to the Council and Plan Teams during meetings in September-October and November-December. The models all indicated a series of poor year classes from 2001 to 2005. However, the 2006 year class appears to be nearly 2 times higher than the average recruitment. The Council-selected model resulted in an ABC (and TAC, not counting state-waters allocation) of 182,000 t. The spawning biomass is projected to continue a slow decline from 2009 to 2010 before the strong 2006 year class would boost the female spawning biomass from 363,000 t in 2010 to 401,000 t in 2012.

BSAI Flatfish: Some significant model changes for flatfish species occurred in 2008 based on requests for evaluations from the Council. The yellowfin sole and northern rock sole assessment models were revised and converted to account for sexual dimorphism. This change made better use of the available data and reduced the number of assumptions about the population ecology of these stocks. Results were similar to previous model configurations and combined flatfish, but the total flatfish biomass was 13% lower compared to last year's totals. This was largely due to model revisions to arrowtooth flounder and others rather than due to declining biomass trends. As with last year, the Council accepted that estimates of F_{msy}, and the associated uncertainties were adequately estimated (based on fitting a stock-recruitment relationship within the integrated assessment model) for yellowfin sole and northern rock sole. The ABC for yellowfin sole was estimated at 210,000 t—a decrease of 15% from the 2008 ABC level. The arrowtooth flounder biomass remains at high levels and shows a slight increase in trend. Northern rock sole 2009 ABC dropped by a few percent to 296,000 t, and the stock condition continues to show an increase. The flathead sole ABC for 2009 was estimated at 71,400 t, and the Alaska plaice abundance increased resulting in an ABC increase of 20% over the 2008 value to 232,000 t for 2009. "Other flatfish" ABC level was also up 10% to 23,100 t.

BSAI Greenland Turbot: Surveys suggested a slight decline from previous year's results but still indicated that recent recruitment conditions have improved. Since an EBS trawl survey of the slope region (the main habitat region for this stock in the U.S. EEZ) was conducted, the assessment information has improved compared to 2007. Previously, the ABC was kept at conservative levels due to assessment uncertainties and stock structure issues. Because the model and information have improved and because of positive signs of recruitment, the Council's SSC recommended easing the conservative ABC slightly and adopted a stair-step approach towards the maximum-permissible ABC level, resulting in an ABC increase from 2,540 t in 2008 to 7,380 t for 2009.

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 AI. For POP, the 2004-08 EBS biomasses were all higher than during 1983-2003; the AI biomass appears to be steady, and exploitation rates generally have been light. Northern rockfish biomass appears to have been increasing since 1977 due to favorable recruitment. Shortraker rockfish biomass has apparently declined slowly since 1980. Biomass of the blackspotted/rougheye rockfish complex in the AI are increasing since 2002, with a huge 1998 year class. There has been large year-to-year variability in the EBS survey biomass, with 2006 biomass near the high end of 1991-2006 range. Fish previously referred to as rougheye rockfish are now recognized as consisting of two species, the rougheye rockfish (*Sebatses aleutianus*) and blackspotted rockfish (*Sebastes melanostictus*). The blackspotted and rougheye complex has now been separated from shortraker rockfish and is assessed with an age-structured assessment for the first time. The current information on these two species is insufficient to support species-specific assessments. The previous biomass estimate (based on surveys and a multispecies surplus production model) for this group was 10,800 t in the 2006-07 assessments (projected to 2008). However, the age-structured model resulted in a 2008 biomass estimate that is 76% higher. The substantial increase in biomass between the last full assessment and this year's assessment is almost entirely due to the adoption of an age-structured model with a selectivity curve that implies that fish are not caught by the survey until they are relatively old. Because the complex is now assessed with an age-structured model, there is an estimate of spawning biomass for 2009 of 6,540 t which is expected to remain stable.

BSAI Atka Mackerel: The Atka mackerel model estimate of biomass increased by 13% due principally to new data indicating that the magnitude of the 2004 year class was more abundant. A number of model changes were also implemented following the extensive peer review conducted during summer 2008. The projected female spawning biomass for 2009 is estimated at 132,300 t, roughly 54% of unfished spawning biomass and above $B_{40\%}$ level (97,800 t) (Fig. 4). The 2009 ABC recommendation is 83,800 t, a 38% increase from the 2008 ABC level.

By Jim Ianelli

Advances in Skate Management and Research

Skates (family Rajidae) are large bottom-dwelling fishes similar to stingrays (Fig. 5). They are distributed throughout the Gulf of Alaska (GOA), eastern Bering Sea (EBS), and Aleutian Islands (AI). Skates are chondrichthyan fishes, meaning that they contain little bony tissue and have skeletons made largely of cartilage. Along with sharks and rays, they make up the elasmobranchs, a group of fishes typified by sensitive life histories: long life, slow growth, and delayed sexual maturation. As a result, skates are a particular conservation concern in Alaska and elsewhere. There are currently no directed fisheries for skates in Alaska waters, but large numbers of skates are caught incidentally in target fisheries. In the EBS, the Alaska skate (*Bathyraja parmifera*) is the dominant skate species and is caught in the Pacific cod, pollock, and flatfish fisheries. Big (*Raja binoculata*) and longnose (*Raja rhina*) skates are the dominant species in GOA waters and are caught by similar fisheries, as well as the Pacific halibut longline fishery. There is substantial interest in developing skate fisheries in the Gulf of Alaska, but a lack of assessment data and the existing incidental catch have kept this fishery closed since 2005.

NEW POPULATION MODEL FOR ALASKA SKATES

Catch recommendations for species managed by the North Pacific Fishery Management Council (NPFMC) are made using a variety of methods depending on the quality of data available for a species or species complex. These methods are classified into hierarchical tiers, with Tier 1 indicating the highest quality data and Tier 6 the lowest. Until 2008, all skates in Alaska were managed as Tier 5 species. Under Tier 5, a fishing mortality rate (F) equal to the natural mortality rate (M) is assumed to be the upper limit to exploitation, and the

Figure 5. A small Alaska skate with a tag attached to the left wing. The measuring board on which the skate rests is marked in increments of 1.0 cm.

overfishing level (OFL) is calculated as *M* times the biomass of the population (as determined through research surveys). While the Tier 5 approach generally provides a conservative means of setting catch limits, it ignores such important biological information as age at maturity and age and size composition. Population models can incorporate these and many other types of data and are the preferred means of stock assessment for commercially fished species.

In 2007, AFSC researchers Olav Ormseth and Beth Matta created an age-structured population model for the Alaska skate (*B. parmifera*) using Stock Synthesis 2, a computer modeling application created by NMFS scientist Rick Methot. In an age-structured model, the population is described in terms of the proportion of the overall population at each age. Life-history characteristics (e.g., length, weight, maturity status) are all described as functions of age. Inputs to the population are through recruitment, which describes the number of new skates being added through reproduction. Skates are removed from the modeled population through natural mortality and commercial fishing. Among other pieces of information, the model provides estimates of unfished biomass (the biomass that would exist in the absence of all fishing) as well as estimates of current total biomass and spawning biomass.

The creation of this model provides a good illustration of how the different divisions of the AFSC contribute to successful fish management. Research projects conducted by members of the RACE and REFM Divisions provided critical life history information; surveys conducted by RACE yield biomass and length composition data; skate age information is provided by REFM's Age and Growth Program; and fishery catch information comes from the Alaska Regional Office and from fishery observers. The *B. parmifera* model was accepted by the Council in fall 2008 and was used to set catch levels using Tier 3. Under Tier 3, the *F* corresponding to OFL (the catch limit) is the *F* that would reduce the spawning biomass to 35% of its unfished level ($F_{35\%}$). The ABC (the catch target) is achieved by fishing at the *F* that reduces the spawning biomass to 40% of the unfished level ($F_{40\%}$). Thus, the ABC is less than the OFL, and the difference between the two values provides a buffer in the face of uncertainty.

For 2009, the Tier 3 ABC for *B. parmifera* is 25,854 t. In contrast, the Tier 5 ABC for 2009 would be 30,487 t. The difference between the two tiers is likely a result of the late sexual maturation of *B. parmifera* (12-13 years of age), which effectively reduces the spawning biomass of the population. Therefore, Tier 3 management provides for more conservative management of *B. parmifera* in the BSAI. Target fisheries typically remove between 15,000 and 20,000 t of Alaska skates from the BSAI each year. The results of the modeling effort indicate that this level of incidental catch is sustainable. The model will be an important tool in the future when considering the possibility of directed fishing for skates.

SKATE TAGGING PROJECT

Some of the most enduring skate biology questions in Alaska regard the movement of skates. Do they move around much? If so, how far, and when? Does movement behavior change with age? To begin to answer these questions, the AFSC initiated what is intended to be a long-term tagging study of *B. parmifera* in the BSAI in summer 2008. We also anticipate that tagging data will be useful for studying skate growth.

Tagging of skates took place during the RACE Division's summer EBS shelf survey. The extensive coverage of the survey and the regular occurrence of skates in the survey catch made the EBS survey an ideal platform for skate tagging. Skates in good condition were removed from the catch and tagged with plastic tags imprinted with individual tag numbers and contact information. Tags were attached to the left wing of skates (Fig. 5) by inserting the tag through the wing so that the barbed end of the tag was locked between two of the cartilaginous rays that extend outwards from the body cavity. Recovery of tagged skates is expected to occur primarily in the commercial fisheries; each person returning a tag receives a NMFS skate research sweatshirt. In 2008, approximately 1,200 skates were tagged in the EBS. As of December 2008, seven tags had been returned.

By Olav Ormseth

AGE & GROWTH PROGRAM

Table 1. Estimated production figures for 1 January through 31 December 2008. Total production figures were 30,548, with 8,507 test ages and 347 examined and determined to be unageable.

Species	Specimens Aged
Alaska skate	249
Flathead sole	2,859
Rex sole	596
Alaska plaice	339
Dover sole	371
Northern rock sole	1,016
Yellowfin sole	1,272
Bering flounder	58
Arrowtooth flounder	174
Greenland turbot	407
Kamchatka flounder	112
Pacific cod	869
Walleye pollock	11,824
Sablefish	2,327
Atka mackerel	1,125
Pacific ocean perch	1,983
Northern rockfish	535
Rougheye rockfish	1,015
Shortraker rockfish	690
Dusky rockfish	861
Quillback rockfish	41
Warty sculpin	683
Plain sculpin	780
Bigmouth sculpin	90
Yellow Irish lords	272

By Jon Short