Auke Bay Laboratories (ABL)

Genetic Investigation of Chinook Bycatch in BSAI Pollock Fishery

The Bering Sea/Aleutian Island (BSAI) pollock fishery will be partially regulated starting in 2011 through a cap limiting the total number of Chinook salmon that can be taken as bycatch. The details for the cap can be found in Amendment 91 to the Bering Sea and Aleutian Islands Fishery Management Plan. Some of the impetus for enacting this limit was the potential effect of bycatch on declining stocks of western Alaska Chinook salmon and its consequence on subsistence fisheries.

This year, the genetics group at Auke Bay Laboratories (ABL) will be collaborating with the Alaska Department of Fish and Game (ADF&G) to complete a pilot project to analyze a limited number of samples from the Chinook bycatch from the 2008 BSAI groundfish fishery. These genetic samples were collected by the North Pacific Groundfish Observer Program as part of a feasibility study. Although the samples may not be representative of the entire bycatch and, therefore, preclude the determination of unbiased stock estimations for the entire fishery, the data will give indications of presence or absence of specific stocks and establish efficient protocols for future analyses. For example, we are developing new MALDI-TOF (matrix-assisted laser desorption/ionization—time of flight) assays as a way to increase our genotyping capacity and significantly decrease SNP (single nucleotide polymorphism) assay costs. Through contracting, these new MALDI-TOF assays will provide us with an almost unlimited genotyping capacity in a very cost-effective manner. The specific objectives of this bycatch project are to 1) identify the strata for which sufficient numbers of samples from the 2008 Chinook bycatch samples can be analyzed and 2) produce stock composition estimates for that limited strata. Results are anticipated in late 2010.

In addition to Chinook salmon, chum salmon are also captured as bycatch in the groundfish fishery. The largest bycatch occured in 2005 when approximately 700,000 non-Chinook salmon (mostly chum) were taken in the BSAI pollock trawl fishery. While chum bycatch stock composition estimates were produced by our laboratory for the 1994-96 fisheries, an ongoing project led by ABL scientist Chris Kondzela has refocused our efforts to learn about marine distributions of chum salmon populations or of regional aggregations of chum salmon in the Bering Sea by using chum bycatch samples collected from 1988 to 2005. Chris is now working with both Colby Marvin, a contractor, and Tyler McCraney, our new technician, in the genotyping of 13 microsatellite markers for almost 8,000 chum salmon samples. This study and the development of a chum salmon genetic baseline are being done as part of a collaboration with Dr. Anthony Gharrett and Mike Garvin, a Ph.D. student from the University of Alaska.

As part of obligations under the Pacific Salmon Treaty, Chuck Guthrie (Fig. 1) of ABL has been working in collaboration with the ADF&G to quantify the numbers of Canadian sockeye salmon caught in some of the Alaskan fisheries. Chuck has been genotyping each salmon for 44 SNP DNA markers and performing genetic stock identification to determine the stock compositions of the catch. To complete the analyses of the 2006 and 2007 northern boundary sockeye fisheries in Alaska Commercial Fishing Districts 101 and 104, Chuck is working with ABL's mathematical statistician Michele Masuda and biological science technician Hanhvan Nguyen. They will soon begin the analysis of 6,000 sockeye samples collected from the 2008 fishery.

The ABL genetics group is also investigating various forage species. In addition to supporting a significant commercial fishery in parts of Alaska, Pacific herring form a critical forage base for many high-profile species including whales, sea lions, Pacific salmon, and Pacific halibut. The herring population in Lynn Canal (near Juneau, Alaska) has been struggling since the late 1970s. Although the commercial herring fishery has been closed since 1981, Lynn Canal herring have not fully recovered, and the National Marine Fisheries Service (NMFS) was petitioned in 2007 to list Pacific herring in Lynn Canal for protection under the Endangered Species Act. Using 16 microsatellite markers, Sharon Wildes has been working to determine the uniqueness of Lynn Canal herring relative to other herring populations in Southeast Alaska. She is now in the process of analyzing her results and preparing them for publication.

By Jeff Guyon

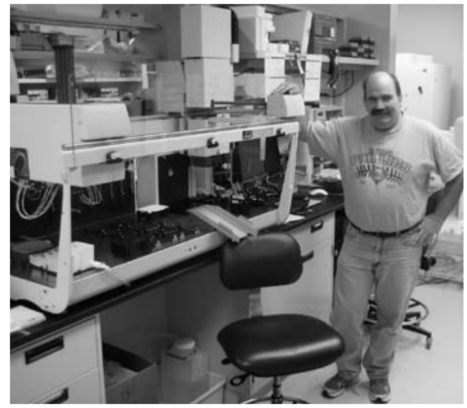


Figure 1. Chuck Guthrie next to the Perkin Elmer Janus Robot. The new robot helps the ABL genetics laboratory set up over 500,000 genotyping reactions each year. Photo by Jeff Guyon.

Fisheries Monitoring & Analysis (FMA) Division

FMA Works to Prevent Injury and Death While Embarking and Disembarking a Vessel

Brian Mason attended the International Fisheries Industry Safety and Health (IFISH) Conference in Reykjavik, Iceland, in May. This biannual conference was the fourth of its kind and brought together numerous professionals with an interest in fishing vessel safety. Key themes of the conference were the relationship between fisheries management and safety and sea safety collaborations between developed and developing nations. At the conference, Brian presented a paper on preventing injury and death while embarking and disembarking commercial fishing vessels. NMFS, the U.S. Coast Guard, and the National Institute for Occupational Safety and Health (NIOSH) were all represented from the Alaska Region.

Commercial fishing in Alaska is among the most dangerous occupations in the United States. According to NIOSH, the annual fatality rate of commercial fisherman in 2007 was 28 times greater than the rate for all U.S. workers. Many safety improvements have been made in recent years, and the death rate for commercial fishermen in Alaska has declined since the early 1990s. In the U.S. commercial fishing industry, 13 persons died while embarking or disembarking a fishing vessel in 2000-08. None of these victims were wearing a personal flotation device (PFD), and all died from drowning. (Commercial Fishing Incident Database (Data file queried July 2009). Anchorage, Alaska: NIOSH).

Over the years, numerous FMA staff and North Pacific groundfish observers have been exposed to the dangers of embarking and disembarking a vessel. Recent experiences in 2009 highlight the danger. In June, an observer narrowly avoided a serious injury when she fell into the water while attempting to board her vessel. Fortunately, she was recovered from the water with only minor injuries due to the quick actions of dock personnel. In April an observer avoided falling into the water only due to the presence of a safety net tied between the dock and the vessel. It is worth noting that a simple precautionary measure, a net, may have prevented a more serious injury or death. Both incidents highlight the need for preventive measures along with a PFD to improve the chances of survival should one fall into the water.

To better understand the scope of the dangers of embarking and disembarking a vessel, the FMA Division conducted a survey in 2008 which confirmed our anecdotal observations that procedures and equipment for embarkation and disembarkation were lacking and that the lack of procedure and equipment was more pronounced on smaller vessels. As a result of the survey, we implemented several efforts to improve the safety of observers and staff boarding vessels. First, staff now are required to wear a PFD when visiting a vessel. We also require all observers to take and wear PFDs during their deployments. Field staff have also worked with plant personnel to increase safety by installing nets when boats are tied up. More work can be done in this area, but each step is an improvement.

Preventing injury and death while embarking and disembarking is the responsibility of everyone involved: industry, observers, and NMFS. The FMA Division is working to improve safety by collecting and sharing information and providing key pieces of safety equipment to minimize the risk of injury or death in the event of an accident.

By Allison Barns and Brian Mason

National Marine Mammal Laboratory (NMML)

ALASKA ECOSYSTEMS PROGRAM

NMML Reference Collections

Two important research collections are maintained at the National Marine Mammal Laboratory (NMML). The NMML Food Habits Collection consists of more than 8,000 fish skeletons, pairs of otoliths, and cephalopod beaks, as well as whole squids and octopuses. Specimens from known species are used by Alaska Ecosystems Program (AEP) and California Current Ecosystems Program (CCEP) biologists to identify undigested prey parts found in pinniped scats (collected from haulouts or rookeries) or in the stomachs of stranded or incidentally taken pinnipeds and cetaceans. Marine mammal food-habits data are used in conjunction with satellite telemetry and dive records to better understand foraging behavior and prey selection. This information is critical to understanding how commercial fisheries and changing environmental conditions affect marine mammals.

The NMML Food Habits Collection is not only important to the ongoing work within NMML, but it also is used several times a year by a wide range of graduate students and researchers from universities, government agencies, and private institutions in Washington, Oregon, California, and Hawaii. The collection has contributed to food-habits research on animals as varied as Magister armhook squid, northern fulmars, Newell's shearwaters, Hawaiian petrels, river otters and, of course, marine mammals. The collection is used as well by local archeologists to determine the identity of fish bones found in Native American middens in western Washington and British Columbia.

Although our Food Habits Collection includes fish and cephalopod species that

Observer Charles Buckley ponders how to safely embark his vessel. Photos by observer Caroline Robinson.

A crewmember assists observer Charles Buckley by standing on the line to bring the vessel closer to the dock.

Observer Charles Buckley makes the crossing to his vessel safely as a crewmember stands by.

are most commonly consumed by pinnipeds along the West Coast and in Alaska, we are in the process of adding other potential prey species as well as unrepresented size ranges of current species. We are very appreciative of ongoing efforts by AFSC Resource Assessment and Conservation Engineering (RACE) Division fisheries biologists to collect specimens during their summer surveys of the Bering Sea shelf and Gulf of Alaska. We are also grateful to the Alaska Department of Fish and Game for contributing fish from Cook Inlet and the Chukchi Sea and to the University of Washington for donating a series of freshwater fish from the Columbia River. With the help and cooperation of researchers such as these, our collection continues to grow in size and value.

NMML is also home to a Marine Mammal Osteological Collection, commonly referred to as "the bone collection." This research collection consists of approximately 2,500 specimens (of post-cranial skeletons and skulls) from 37 species of pinnipeds and cetaceans from around the world. Specimens have been collected over the past 60 years during research projects that have included pelagic sealing in the 1950s, life-history studies of small cetaceans incidentally taken in foreign and domestic set and drift-net fisheries, and life-history and ageing studies of pinnipeds and cetaceans that have stranded on beaches and rookeries from Alaska to the Antarctic.

The NMML Osteological Collection also houses vast numbers of marine mammal teeth. The largest collections are from northern fur seals taken during commercial and subsistence harvests on the Pribilof Islands, Steller sea lions taken incidentally in Alaska fisheries, and sperm whales collected from Pacific Coast whaling stations in the 1950s and 1960s. The majority of these teeth were initially collected for ageing studies, but in recent years, many have been used in stable isotope, nursing, and growth layer/growth index studies.

Several species of cetaceans and pinnipeds are represented in the NMML Osteological Collection by particularly large series of specimens that, like the teeth collections, continue to be used today. Southwest Fisheries Science Center biologists, along with marine mammalogists from the University of California, Texas A&M University, and Purdue University have used the NMML bone collection in recent years. Archeologists looking at midden material from Alaska to Mexico are also regular visitors to the collection. The NMML bone collection is also an important part of the AFSC Outreach Program's curriculum. Approximately twice a month, Outreach Program members conduct interpretive tours of the bone collection for students and teachers from local elementary schools, middle schools, and high schools.

The NMML Food Habits and Marine Mammal Osteological reference collections are irreplaceable assets used by NMML and the larger scientific community to further their understanding of marine mammal biology. The value of these collections for future research will only increase as global climate change continues to impact marine communities around the world.

By Jim Thomason

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

The Ice Whale in the Sea of Okhotsk

Bowhead whales, *Balaena mysticetus*, are found only in the Northern Hemisphere and are closely associated with sea ice—so much so that they are known to Alaskan and other native people as the "ice whale." Currently, five populations of bowheads are recognized. The best known one is in the "western" Arctic off Alaska and western Canada; this group inhabits the Bering, Chukchi, and Beaufort Seas and is duly known as the "BCB" stock. There are also three recognized populations in the North Atlantic off eastern Canada, Greenland, and the Norwegian island of Spitsbergen.

The fifth bowhead whale population is an apparently separate and historically isolated group in the Okhotsk Sea (OS). Comparatively little is known about this stock. Certainly, the population was greatly reduced by whaling in the 19th century and, more recently, by illegal catches made by the U.S.S.R. The typically difficult conditions with which bowhead whale biologists must contend are exacerbated in the Okhotsk Sea due to the remoteness of the area, the low human population size, and the absence of development and facilities in much of the region, notably in the northern portion of this sea.

Recently, for a project funded by the U.S. Marine Mammal Commission and submitted to the journal Mammal Review (Ivashchenko and Clapham in press), we reviewed current knowledge regarding bowhead whales in the Okhotsk Sea, concentrating especially on their seasonal distribution (both historically and today) and relative abundance. In addition to well-known historical materials and other publications, we drew upon previously untranslated Russian language reports of marine mammal surveys in the region. We reviewed the available literature on OS bowheads in both English and Russian. This literature can be broadly divided into three types or sources: 1) historical information, largely whaling data; 2) Japanese sighting surveys; and 3) Russian or Soviet reports and papers—in most cases previously unavailable in English—giving results of surveys (some directed and others opportunistic or focused on other taxa). The majority of recent information comes from the last source, which is not surprising given that most of the Okhotsk Sea lies within the jurisdiction of the Russian Federation (and formerly of the Soviet Union). The quality of individual Russian reports varies considerably from quite good to very vague or confusing; however, our access to both English and Russian texts has provided greater detail than has been possible in past attempts to clarify the results of these surveys.

The Okhotsk Sea is the world's ninth largest body of water; it is bounded by mainland Russia to the west and north, the Kamchatka Peninsula to the east, and the island of Hokkaido (Japan) and the Kuril Islands to the south. Because of strong seasonal productivity, the region supports large numbers of marine mammals, including several species of large whales. In winter, the Okhotsk Sea is primarily covered by ice except for waters near Kamchatka and the Kuril Islands. Overall, the Okhotsk Sea possesses physical and oceanographic characteristics of both Arctic and temperate seas.

The Okhotsk Sea was the site of an intensive 19th-century whale fishery that was dominated by American whalers, although other nationalities (notably British and French) also operated there. The renowned whaler and naturalist Charles Melville Scammon (1874) noted, "The Okhotsk Sea at one time equaled if not sur-

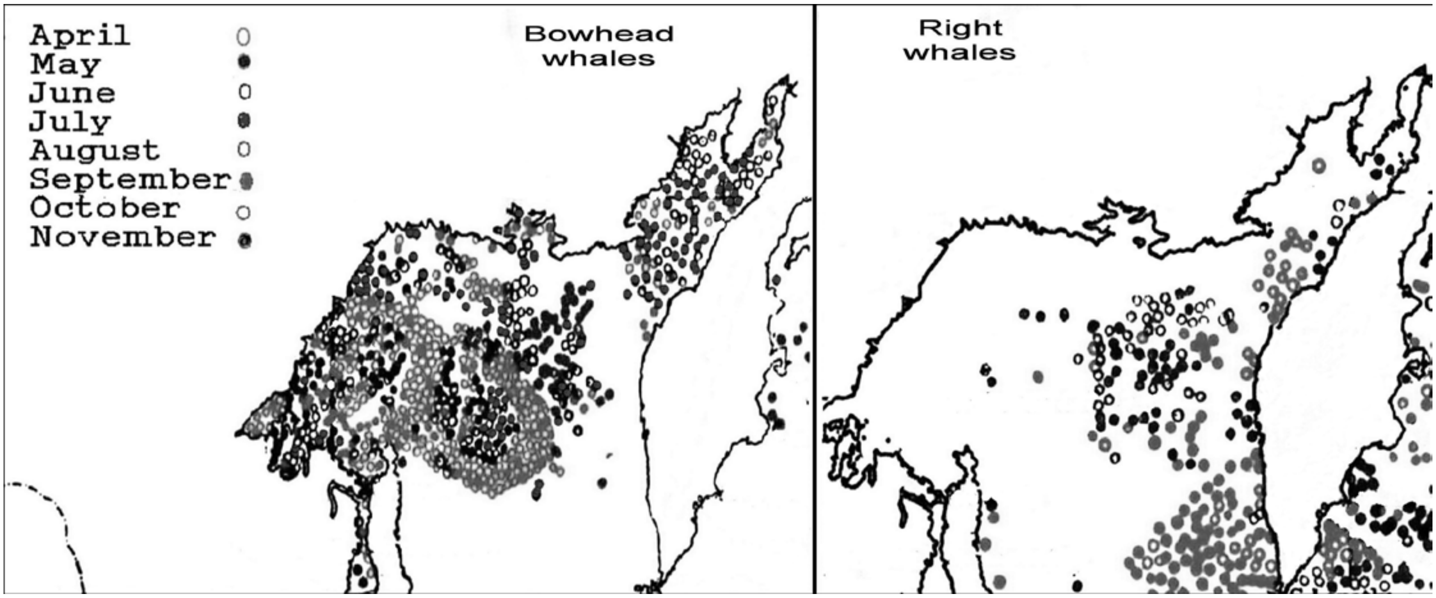


Figure 1. Distribution of bowhead whales in the Okhotsk Sea according to whale catches plotted by Townsend (1935).

passed the Arctic as a productive whaling ground." Despite this history, the OS fishery remains poorly documented. Whaling for bowheads in the Okhotsk Sea began sometime around 1846 in Taouyskaya Bay (near Magadan in the northern Okhotsk Sea). By 1854, the Okhotsk Sea became the center of much whaling activity for a few years, and by 1860 about 200 whaling vessels were operating, primarily in the Shantar area. Scammon provides a detailed and colorful description of the whaling business at Shantar, including a note that in the early years of the fishery the bays were so full of whaling ships that extreme care had to be taken to avoid collision in the dense fog and ice that occurred there, notably at the beginning of the whaling season in June. Evidently the waters around Shantar were characterized by considerable bioluminescence; Scammon adds the note that, as summer advanced and daylight became shorter, "night-whaling" was frequently practiced, with the "phosphorescent light caused by the whale's movements in the water [showing] quite distinctly his whereabout."

The total number of catches remains unclear, and various efforts to estimate the original population size have yielded substantially different numbers. After the OS populations of bowheads and right whales had been rendered commercially extinct, whalers paid no attention to the area until 1967, when the Aleut whaling fleet from the U.S.S.R. began to hunt bowhead whales in the Shantar region. Because bowheads had long been protected by the International Whaling Commission, and because the U.S.S.R. was a signatory to the International Convention for the Regulation of Whaling (1946), all of these catches were illegal; the bowhead takes were a small part of a large worldwide campaign of illegal Soviet whaling (Clapham and Ivashchenko 2009). The total number of Soviet catches of bowheads in the Okhotsk Sea during the period of illegal whaling is unknown. However, this hunting again depleted the already small population and, thereby, further inhibited its recovery.

There is no good estimate of current abundance for bowhead whales in the Okhotsk Sea, although some scientists have assumed from general sighting rates since the 1980s that it is in the low hundreds. Genetic comparisons of OS and BCB bowheads using both mitochondrial DNA and microsatellites have revealed significant genetic differences between the two populations, consistent with a common ancestry but no mixing in the recent past.

In a fascinating and often amusing memoir from 1888, the whaler Otto Lindholm noted reports that some bowheads killed in the Okhotsk Sea had old harpoons embedded in them, bearing the names of whaling ships that had only whaled in the Arctic. However, he largely discounted this evidence for mixing between the two populations, noting that it was common practice for harpoons and other whaling equipment to be sold in the major Hawaiian provisioning and layover port of Honolulu (and, presumably, also in Lahaina). Scammon (1874) states, "no Bowheads of the Okhotsk Sea have ever been seen passing in or out of the passages of the Kurile Islands, or from the Okhotsk to Behring Sea, or Arctic whales passing to the Okhotsk." On the basis of current evidence, there is no reason to doubt the current belief that OS bowheads constitute a discrete population and never leave the Okhotsk Sea.

Information on historical and current distribution comes from whaling records (Fig. 1) and from modern (notably Russian/Soviet) marine mammal surveys (Fig. 2). Little is known about winter distribution, but sightings of bowheads in pack ice in the Okhotsk Sea and elsewhere contradict the popular view that this species winters exclusively along the ice edge or in polynyas. In spring and summer, known bowhead concentrations occur in Shelikhov Bay and at Shantar. Although historical whaling data show bowheads in Shelikhov Bay in summer and early autumn (Fig. 1), recent sightings in this area have not occurred later than June. However, extensive 19th-century catches were made over much of the northern Okhotsk Sea, and the present range and habitat use of the population is likely broader than existing data suggest. There is equivocal evidence for age/class segregation between Shantar and Shelikhov

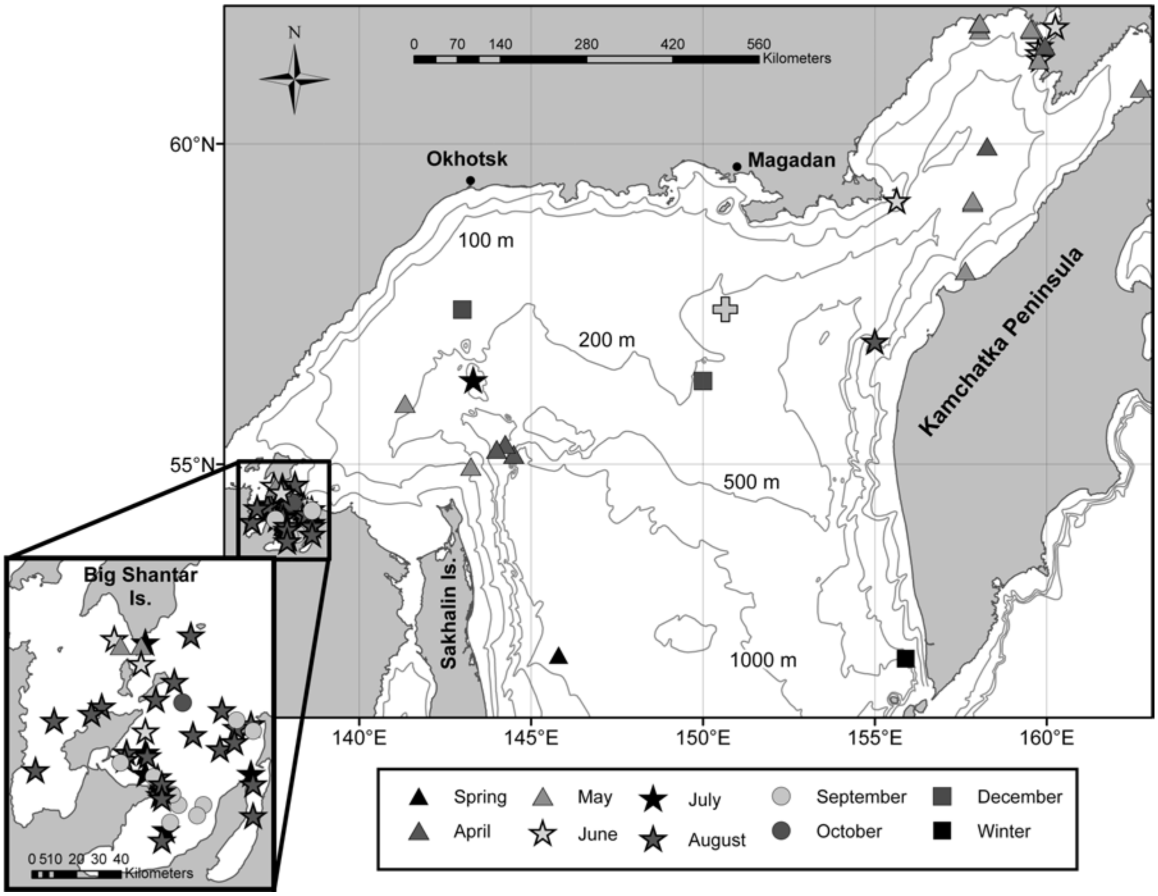


Figure 2. Reported sightings of bowhead whales in the Okhotsk Sea from 1967 to the present.

Bay, with the former hosting immature whales and lactating females and the latter used by adults.

Overall, it is apparent from our review that the bowhead whale population in the Okhotsk Sea is separate from the closest neighboring stock in the BCB region, remains relatively small and unrecovered, and probably still occupies much of its historical range in the northern Okhotsk Sea, from Shantar to Kashevarova Bank and Shelikhov Bay.

There is little information regarding current threats to this population, although at least one whale has been reported killed through entanglement in a deep-water crab fishery; anecdotal reports of other entanglements exist. Given the population's continued endangered status, further work on Okhotsk bowheads is urgently required. Further assessment of the status and conservation needs of this population cannot be undertaken without dedicated surveys of known and likely habitats in the northern Okhotsk Sea. Current knowledge would suggest that future effort should focus on the areas identified above (Shantar, the Taouyskaya Bay area south of Magadan, Kashevarova Bank, and Shelikhov Bay). However, prior to conducting such surveys, it would be useful to revisit historical whaling data and clarify the extent of overlap between bowheads and right whales in the Okhotsk Sea; this information, together with more recent data summarized here, could then be used to identify potentially key habitats and to better plan future surveys. Such surveys, as well as satellite tagging to assess individual movements, are critical for the future management of this once-heavily exploited population.

By Yulia Ivashchenko and Phil Clapham

POLAR ECOSYSTEMS PROGRAM

Telemetry of Ice Seals Captured During a Research Cruise Aboard the McArthur II in the Eastern Bering Sea

The National Marine Mammal Laboratory's Polar Ecosystems Program (PEP) participated in an ice-seal research cruise in the eastern Bering Sea this spring, 13 May–11 June 2009, aboard the NOAA ship *McArthur II*. A primary objective for the cruise was to deploy satellite-linked tags on ribbon and spotted seals. Ribbon seals and spotted seals are closely associated with sea ice during this time of year. The data collected by the satellite-linked tags will, together with information collected during similar cruises since 2005, provide critical information on haul-out and dive behavior and seasonal movements. Both ribbon and spotted seals have been the subject of petitions for listing under the U.S. Endangered Species Act, primarily out of concerns about global warming and the loss of sea-ice habitat. Information on the timing of haul out is critical for calculating abundance estimates from previous aerial surveys, and data on movements and dive behavior will help to identify important habitat.

We captured 69 seals in all, comprising 37 ribbon, 31 spotted, and 1 ringed seal. We attached satellite transmitters to 22 ribbon and 30 spotted seals. Most of the transmitters were SPOT tags (Wildlife Computers,

Figure 3. Preliminary map of ribbon seal movements from ARGOS satellite tags, May–July 2009.

Figure 4. Preliminary map of spotted seal movements from ARGOS satellite tags, May–July 2009.

Redmond, WA), attached to the seals' hind-flippers, which will provide long-term movement data and haul-out timelines—but only when the seals are hauled out with their flippers exposed. The remaining transmitters were SPLASH tags (Wildlife Computers) which provide more detailed information about locations at sea and diving behavior; these tags must be glued to the hair on the seal's back or head and thus could only be attached to seals that had sufficiently completed their annual molt.

The *McArthur II* departed Kodiak, Alaska, on the afternoon of 13 May and arrived at the ice edge and began research operations on the morning of 16 May. A typical day consisted of survey watches from 9 a.m. to 9 p.m. Alaska Daylight Time (about 6 a.m. to 6 p.m. local apparent time), interrupted by small-boat excursions to capture and tag seals when we encountered sufficient concentrations of seals and suitable ice. Seals were captured on ice floes with hand-held landing nets. Our field crew consisted of eight PEP biologists and one veterinarian. We conducted surveys or tagging operations daily until the evening of 8 June. The *McArthur II* returned to Dutch Harbor, Alaska, on the morning of 11 June.

The sampling for each seal typically included length and girth measurements, mass, blood, a small piece of skin for genetics analysis, and any fecal material that was present on the ice for diet analysis. We obtained 61 blood, 67 skin, 67 viral swab, and 33 fecal samples from seals that we captured. In addition, we were able to collect 10 fecal samples and 17 samples of skin shed during the molt from seals that escaped our capture attempts. The dark flakes of skin are easy to find in the vicinity of the molting seals' resting sites, and they contain sufficient DNA to support genetic analyses for investigation of stock structure.

Data from the deployed tags are already providing information (Figs. 3, 4). As observed from tags deployed in previous years, both ribbon and spotted seals have a strong association with the sea ice. As sea ice retreated in early summer, the spotted seals tended to head towards more coastal habitats along Alaska or Russia, while ribbon seals remained in the ice-free waters near the shelf break and over the Aleutian Basin.

By Michael Cameron, Josh London, and Peter Boveng

Testing a Ship-Based Unmanned Aerial Aircraft System (UAS) for Surveying the Bering Sea Pack Ice

The Polar Ecosystems Program (PEP) conducted tests of an unmanned aerial aircraft system (UAS) to determine its effectiveness for surveying subarctic pack ice for ice seals. The tests were conducted as part of a research cruise in the eastern Bering Sea this spring, 13 May–11 June 2009, aboard the NOAA ship *McArthur II*.

Over the next several years, NOAA intends to gain the capability to incorporate UASs as a tool for collecting data relevant to its science goals. Before broad-scale surveys using UASs can be conducted, however, platforms and instruments must be evaluated to ensure that mission goals can be effectively met. The PEP usually conducts aerial surveys for ice seals using helicopters based from a U.S. Coast Guard ice breaker. NOAA's UAS program identified the Arctic and subarctic as areas of special interest and so chose to test the effectiveness of a UAS for surveys in these areas.

The UAS used in these tests was the ScanEagle, by Boeing, primarily because it was specifically designed to be launched and re-

Figure 5. ScanEagle unmanned aerial aircraft system (UAS) ready for launch with propeller guard in place.

Figure 6. The SkyHook recovery system is composed of a line suspended between the ship's crane and a lower boom.

Figure 7. ScanEagle UAS about to capture the SkyHook line for recovery.

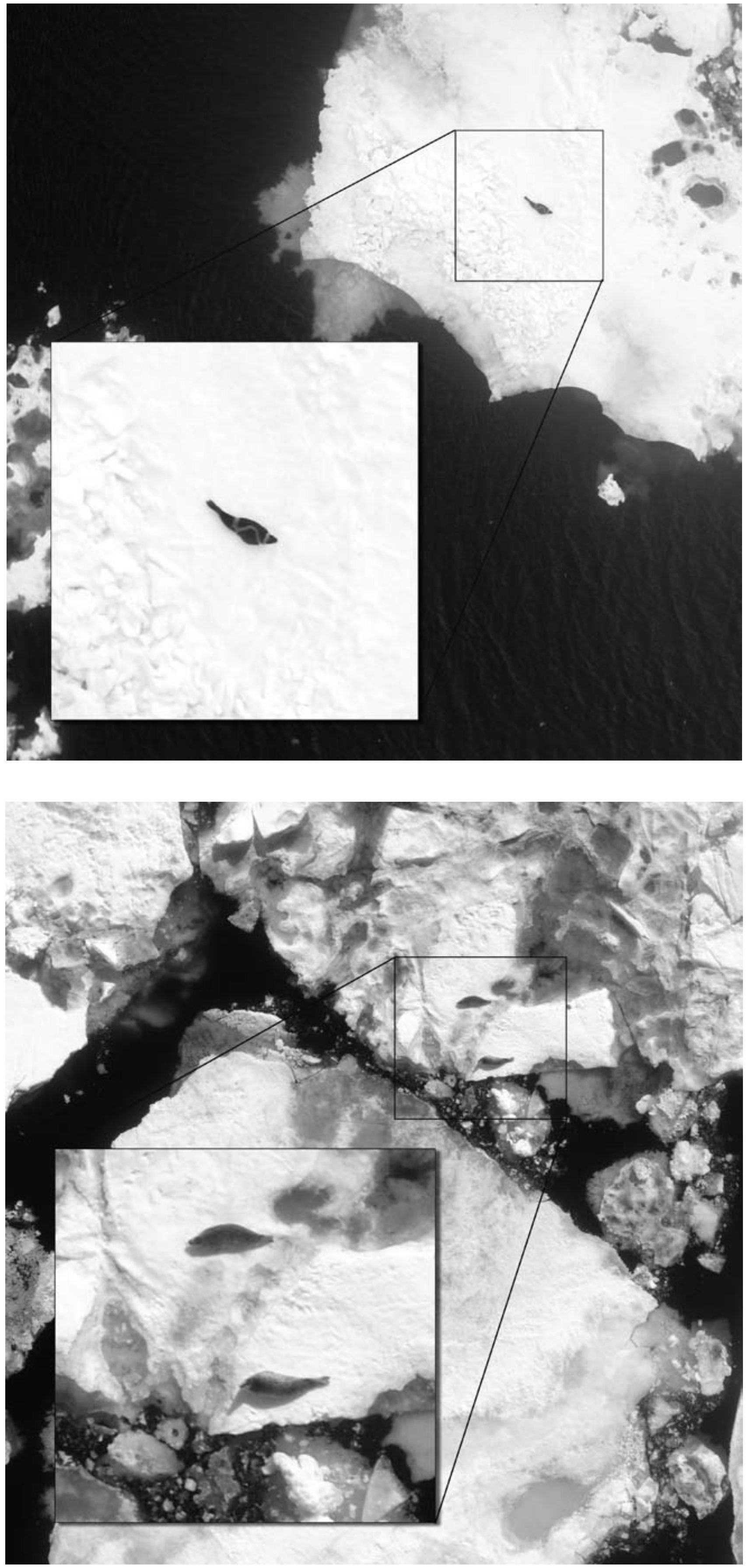


Figure 8. Images of Bering Sea ice seals (ribbon and spotted) taken from the ScanEagle UAS at altitudes of 300 and 400 ft, during the *McArthur II* UAS ice-seal cruise.

covered from a ship at sea. We tested three different ScanEagles (Fig. 5), which were owned and operated by the University of Alaska Fairbanks. The ScanEagle has a 4-ft long body, a 10-ft wingspan, a cruising speed of 48 knots, and a flight endurance of 20+ hours. The ScanEagles were launched by pneumatic catapult from the winch deck and captured by a SkyHook system (Figs. 6, 7), where a clip at the end of each wing captures a line suspended from the starboard crane to a lower boom. The lower boom extended across the deck, under the rail, and out over the water approximately 25 ft from the ship and 10 ft above the water.

Two of the aircraft carried a downward-facing digital SLR camera (Nikon D300) in a belly-module component of the aircraft body. The camera was programmed to collect geo-rectified images every 4 seconds. In addition, a fixed video camera was also in the nose cone of these two platforms. The third aircraft did not carry the digital SLR package but had an integrated video camera that could be controlled (e.g., pan, tilt, and zoom) from the ground station (ship).

We received a Certificate of Authorization (COA) from the Federal Aviation Administration to fly the UAS. The general requirements included conducting flights within designated airspace in the central-east Bering Sea and maintaining a buffer of 20+ nautical miles (nmi) from the Russian border and any other inhabited land mass. The UAS airspace extended to an altitude of 3,000 ft and a 5-nmi radius from the ship. When the aircraft was within 3 nmi of the ship, one observer was required to be outside looking for other aircraft in the area. When the aircraft was 3-5 nmi from the ship, two observers were required.

Two initial test flights had been conducted on 4 May 2009 in the restricted airspace near the Whidbey Island Naval Air Station at Admiralty Inlet in Puget Sound. We conducted 10 additional UAS flights at the Bering Sea ice edge between 21 May and 8 June 2009. The digital SLR camera payload was carried on eight of these flights and collected over 25,000 images of sea ice (Fig. 8). These images are currently being analyzed for the presence of ice seals.

The ScanEagle performed well in a variety of weather conditions, and the images collected have the necessary resolution to distinguish the different species, ages, and occasionally even the gender of ice seals.

By Michael Cameron, Erin Moreland, and Peter Boveng

Resource Assessment & Conservation Engineering (RACE) Division

GROUNDFISH ASSESSMENT PROGRAM

First Comprehensive High-resolution Mapping of Pribilof Canyon

The first comprehensive mapping survey of the Pribilof Canyon area in the eastern Bering Sea (EBS) (Fig. 1) was completed June 2009 using high-resolution multibeam echosounders. Only sparse trackline data from reconnaissance and other opportunistic surveys have been available previously to describe the morphology of Pribilof Canyon, one of a family of huge canyons that play a central role in supporting the rich ecosystem of the Bering Sea.

Submarine canyons are significant geological features that cut the continental slope and function as conduits for organic and inorganic matter moving between deep basins and the continental shelf. The resulting fluxes can support diverse communities with high biomass, as compared to non-canyon regions at similar depths. Canyons are rare habitats, occupying less than four percent of the world seafloor and commonly contain unique species assemblages.

There are at least 15 distinct canyon systems along the EBS continental shelf, including the three largest submarine canyons in the world. Zhemchug is the largest of these; each of its two main branches is larger than typical continental shelf canyons (e.g., Monterey). Pervenets and Pribilof Canyons are substantially smaller. Two canyons (Middle, St. Matthew) were discovered as recently as 1982. Despite relatively extensive geological studies of submarine canyons in the EBS, very little biological information is available to assess the value of canyon habitats.

Planning for the Pribilof Canyon mapping project began in October 2008 when the Resource Assessment and Conservation Engineering (RACE) Division was approached by the Marine Conservation Alliance Foundation (MCAF), a diverse group of fishing and community organizations working to promote the sustainable use of North Pacific marine resources (on the web at www.marineconservationalliance.org/about.html). At that time, MCAF requested technical assistance to develop the first phase of a potentially longer-term

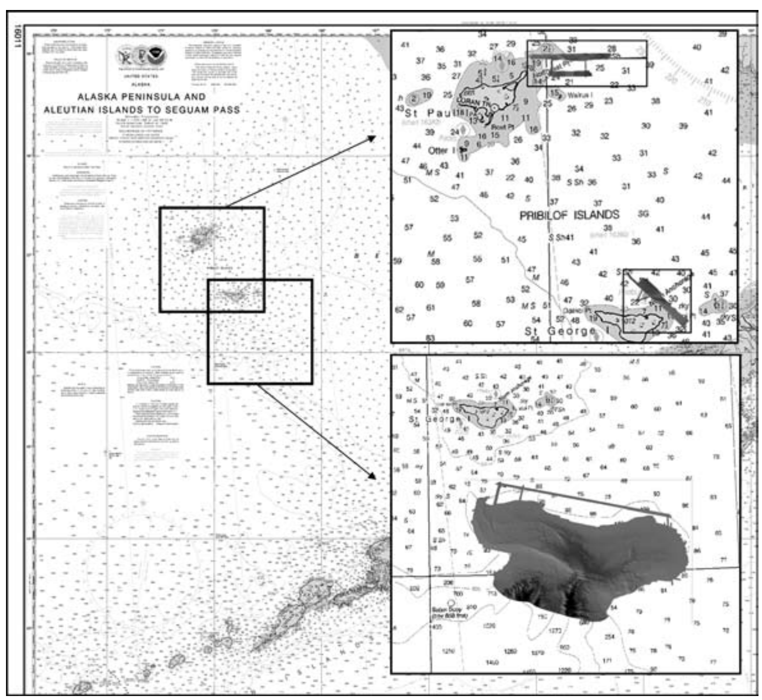


Figure 1. The survey area in the eastern Bering Sea included Pribilof Canyon and two relatively small and shallow areas near the Pribilof Islands. Both water depths and seabed backscatter were measured with high-resolution multibeam echosounders. Depths are represented above in shades of gray ranging from light gray (shallowest) to gray-black (deepest).

study investigating the fisheries habitat features found in Pribilof Canyon and the potential impacts of derelict or lost fishing gear that form marine debris. Based on a review of research priorities and existing knowledge of the area, it was decided to conduct a baseline hydrographic survey of the area with full multibeam bathymetric coverage and coregistered backscatter from the seabed. The resulting information would serve as the backdrop for developing scientific investigations of specific benthic habitats and associated organisms, as well as more exploratory work with manned and unmanned submersibles.

A unique and complex partnership was formed during the project planning period, consisting of three NOAA line offices (NMFS, National Ocean Service (NOS), Office of Oceanic and Atmospheric Research (OAR)), the University of Alaska Fairbanks, and MCAF. The partners contributed technical expertise, personnel and/or funding to expand the original project scope from fishable areas of Pribilof Canyon (200-1,100 m depths) to include deeper canyon areas to 2,200 m. Two relatively small and shallow areas near the Pribilof Islands were also added because of potential importance as king crab habitat (total area 50 nmi^2). The ensuing field operations conducted 2-17 June 2009 accomplished multiple coordinated objectives with efficient use of limited resources.

Overall, more than 1,200 linear nmi (approximately 900 nmi^2) in the canyon were surveyed simultaneously with two high-resolution multibeam echosounders (70-100 kHz Kongsberg model EM 710 and 12 kHz Kongsberg model EM 120) installed on the chartered research vessel *Mt. Mitchell*. Surveyors from Terrasond Ltd. with support from Lt.(jg) Meghan McGovern, a benthic habitat mapping specialist and NOAA Corps hydrographer assigned to the RACE Habitat Research Group, collected full-coverage bathymetry (Fig. 2) according to NOAA hydrographic specifications as well as the corresponding backscatter (Fig. 3).

After processing is completed, these data will be used to address the following mission objectives: 1) identify areas that are potentially hazardous for loss of commercial fishing gear and creation of marine debris, 2) produce quantitative measures of canyon morphology and habitat characteristics, and 3) provide high-quality hydrographic data for updating NOAA nautical charts and planning future research in the area.

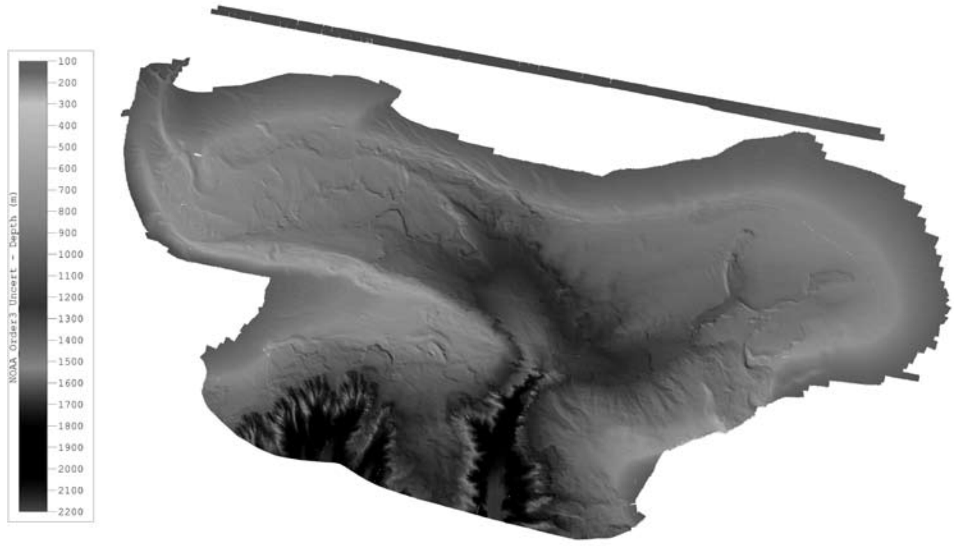


Figure 2. Preliminary multibeam bathymetry for a nearly 900 nmi^2 area in Pribilof Canyon (20 m spatial resolution).

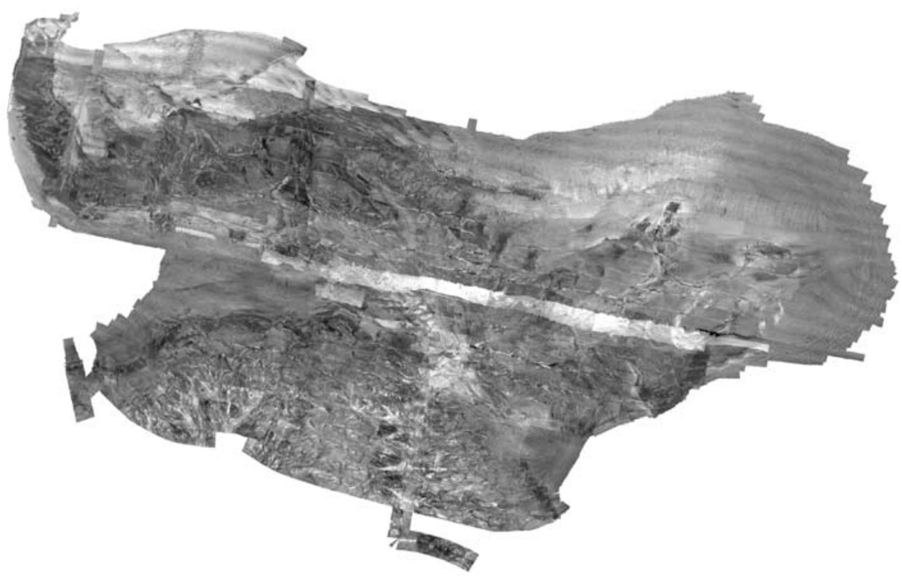


Figure 3. Preliminary multibeam backscatter in Pribilof Canyon (0.5 m spatial resolution). Shades of gray represent variations in seabed composition and texture.

By Bob McConnaughey and Meghan McGovern

Trawl Impact Research Presentation by Visiting Scientist

Dr. Roland Pitcher with the Australian Commonwealth Scientific and Industrial Research Organization (CSIRO) presented a seminar titled "An integrated approach to assessment of seabed habitat and biodiversity in support of trawl management on the continental shelf of the Great Barrier Reef" on 6 April at the AFSC in Seattle, Washington. His talk summarized a series of related research projects over the last 15 years in the Great Barrier Reef that assessed the impact rates of bottom trawling for prawns on megabenthos; monitored subsequent recovery rates and measured natural dynamics of sessile megafauna; mapped the distribution of seabed habitats and megabenthos species; and integrated these results with fishery effort data in a dynamic modeling framework. This framework was then used to evaluate alternative strategies for sustainable management of these species. The methods he described included direct sampling with benthic sleds and bottom trawls, underwater video, and statistical modeling to predict the distribution of species from biophysical relationships with broad-scale datasets such as bathymetry, sediments, remote sensing, and oceanographic model output. The modeling framework simulated trawl impact and recovery for the predicted species distributions, based on measured estimates of rates and existing data on trawl effort distribution and intensity, in order to estimate the regional scale implications of past trawling. An evaluation of management actions over the last 10 years showed that effort reductions lead to positive responses in benthic invertebrate populations, while spatial closures of low effort areas had negligible responses. AFSC staff had an opportunity to meet informally with Dr. Pitcher to discuss their personal research problems and the applicability of his analytical methods in Alaska. This work is particularly relevant to the research plan that is currently being developed for the Northern Bering Sea Research Area.

By Bob McConnaughey

Planning Ahead for the Northern Bering Sea Research Area (NBSRA)

Receding sea ice in the northern Bering Sea (NBS) appears to be shifting the ecosystem in favor of some groundfish species. As recent AFSC bottom trawl surveys indicate, the distributions of some commercial fish and crab populations are extending northward into the subarctic bounds of the NBS. This trend is expected to attract a corresponding movement of the Bering Sea nonpelagic bottom trawl fleet, which targets mainly flatfishes such as yellowfin sole, rock sole, flathead sole, turbot, and arrowtooth flounder.

Historically, commercial bottom trawling effort has been negligible in the remote and often ice-locked NBS. Fishery and ecology research also has been limited there. However, many marine mammal and seabird species have long thrived in this rich, benthic-based ecosystem, feeding on the abundant clams, crustaceans, and other invertebrates on the seabed. Some of these benthic predators are currently listed under the Endangered Species Act, such as the spectacled and Steller's eiders, or are under consideration for listing, such as the walrus. At the top of the food web are native Alaskan peoples, who have subsisted for generations in coastal communities through fishing and hunting. Climate change and commercial bottom trawling can potentially cause adverse effects on the environment and the subsistence coastal communities.

Warming of the boreal seas and the loss of sea ice already are changing energy flow through the ecosystem. There has been a significant decrease in benthic productivity and biomass over the past decade. The complex effects of this shift are still little understood but are certain to propagate to upper trophic levels. The additional stress that bottom trawling might impose on the benthic habitats of the NBS and its radiating effects on animals and people are cause for concern. Presently, there is a lack of up-to-date baseline information on the benthic habitats and ecology of the NBS for assessing the effects of bottom trawling.

Amendment 89 to the fishery management plan for groundfish of the Bering Sea and Aleutian Islands management area establishes the Northern Bering Sea Research Area (NBSRA) for studying the impacts of bottom trawling on benthic habitats (Fig. 4). Pursuant to the Amendment, bottom trawling is prohibited in the NBSRA. The North Pacific Fishery Management Council (Council) has requested that the AFSC formulate a scientific research plan to study the benthic habitats of the NBSRA and the potential effects of bottom trawling so as to inform management actions.

The RACE Division is spearheading a joint effort within the Center and the NMFS Alaska Regional Office to develop a research plan for the NBSRA. A preliminary outline of the plan was presented to the Council's Scientific and Statistical Committee (SSC) for review at the June 2009 Council meeting. The plan features trawl impact studies as the principal research element. The proposed studies are modeled after trawl impact experiments (TRAWLEX) conducted in Bristol Bay by the RACE Habitat Research Group (www.afsc.noaa.gov/RACE/groundfish/hrt/impact.htm). In the plan, previously untrawled sites representative of the major benthic habitat types in the NBSRA are chosen for the studies. The impacts of bottom trawling are measured in the biological and physical changes in the benthic habitats before and after trawling. Other proposed research elements are bottom trawl surveys and habitat studies. These studies will provide baseline data on

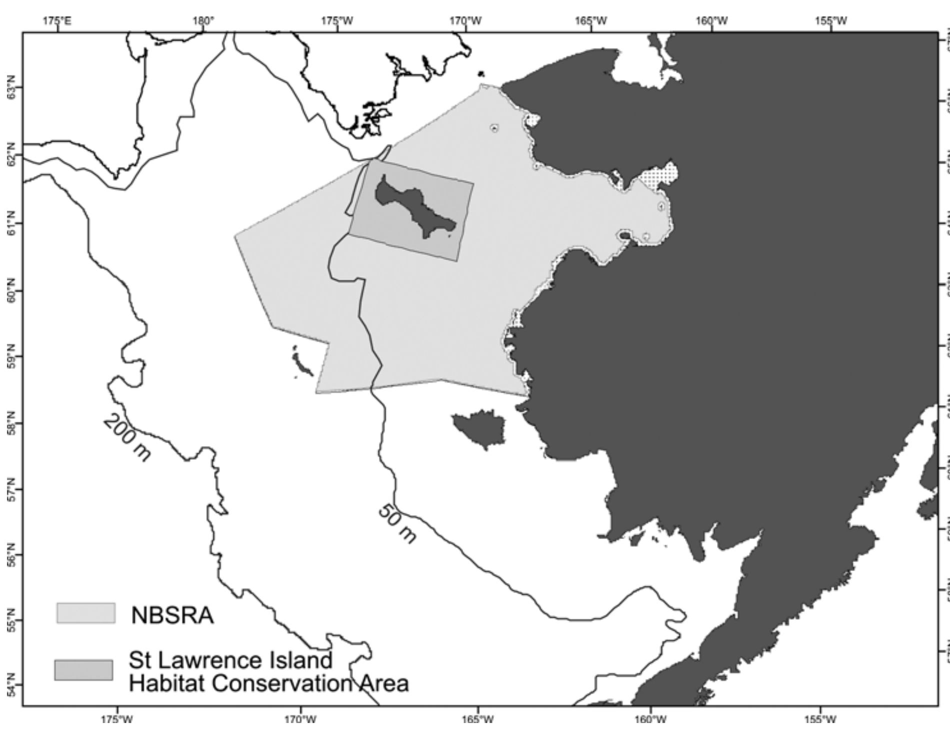


Figure 4. Northern Bering Sea Research Area (NBSRA).

fish population dynamics and the benthic environment. Also suggested in the plan is the granting of exempted fishing permits (EFP) to some commercial trawling vessels for limited fishing in the NBSRA. This will provide more realistic information on catch and effort, fishing patterns, and interactions with nontargeted species and subsistence fisheries.

After reviewing the outline and considering the testimonies of the fishing industry, environment advocates, and Alaskan communities, the Council advised that an extended period should initially be invested in compiling baseline habitat information. The Council believes that a sound research plan requires more substantial knowledge of the environment, species, and people. Further analysis of the plan should follow baseline data compilation and review.

AFSC is focusing on gathering available data, building databases, and producing resource and habitat maps in support of NBSRA research planning. This involves mining information from past studies, canvassing researchers presently active in the NBS, and consulting with government agencies, the fishing industry, and Alaskan communities. Meetings with these different groups are tentatively scheduled for early 2010 to solicit input and forge partnerships in the planning process. The tentative date for completing the final plan is late 2011. Interested parties are kept informed of the developments through the Council website at www.fakr.noaa.gov/npfmc/current_issues/ecosystem/NBSRA.htm.

By Cynthia Yeung

SHELLFISH ASSESSMENT – KODIAK LABORATORY

Rescue and Retrieval of Historic Bering Sea Crab Data

Research concerning the biology, stock abundance, and distribution of crab in the North Pacific Ocean and Bering Sea has been the primary focus of programs at the AFSC's Kodiak Laboratory. Establishing an accurate time series of data related to the eastern Bering Sea king and Tanner crab stocks is necessary to adequately assess these commercially important and fluctuating crab stocks. As part of this effort, the arduous and time-consuming process of error checking and reproducing the data series of annual surveys from 1975 to present was recently standardized by Kodiak Laboratory staff Claire Armistead and Liz Chilton. The database serves scientists within the AFSC as well as agencies and universities involved in research and modeling efforts concerning population dynamics, fishery management, and ecology.

KING CRAB JOHN R. MANNING 1968

TEMPERATURES (°C) (SKT) SURFACE 0.00	(°C) BOTTOM 0.00	CORRECTED SURFACE SALINITIES °/oo	KING CRAB DATA TOTAL	MALES (N) > 145 mm	MALES (N) < 145 mm	FEMALES (N) >100 mm	FEMALES (N) <100 mm
2.7	3.0	31.826	7	6	0	1	0
3.1	3.1	32.045	1	1	0	0	0
3.1	3.1	31.752	62	12	2	42	6
2.3	2.4	31.794	3	0	2	1	0
2.3	1.8	31.738	5	3	2	0	0
2.4	1.4	31.571	26	8	2	14	2
2.3	1.4	31.841	47	4	23	17	3
2.1	1.4	31.578	118	7	52	22	37
2.5	1.4	31.898	571	68	38	363	102
1.9	1.5	31.878	651	23	74	419	135
2.1	1.4	31.559	0	0	0	0	0
2.1	1.4	31.841	111	15	2	79	15

Figure 5. Handwritten table for *John R. Manning* Bering Sea king crab survey, May 1968. USFWS Bureau of Commercial Fisheries.

Pre-1975 archived records exist that include crab survey data, pilot house logs, and research records from the Bering Sea that have not been adequately assessed for accuracy and consistency with the current time series or made available electronically. These historic eastern Bering Sea survey records include embedded environmental data such as bottom temperatures and on-site weather observations. In 1997 and 1998, these records were initially inventoried through a contract funded by NOAA's Earth System Data and Information Management program. In 2008, Kodiak Laboratory staff received a grant from NOAA's Climate Database Modernization Program (CDMP) for scanning and digitizing the archived pre-1975 crab survey data and records. The project continues in 2009.

Initially, crab survey data directly associated with environmental data became the primary focus of the project in an effort to identify the extent of new information not previously published. Thus far, more than 103,000 records (6,200 images) of 1966-74 eastern Bering Sea survey data from the National Marine Fisheries Service and its predecessor agency the Bureau of Commercial Fisheries have been scanned, archived, and entered into database file formats.

Recently, five albums were found containing cruise reports and cruise photographs for the period 1960-1964 and are waiting scanning and digitization.

An example of the types of information that will be analyzed upon completion of the data entry is the 1968 crab distribution compared to bottom temperatures. The data (Fig. 5) were collected aboard the Bureau of Commercial Fisheries research vessel *John R. Manning* (Fig. 6) and will be important when comparing stock abundance and productivity with environmental and ultimately climate-scale variability in the eastern Bering Sea.

Our primary objective for this archival project remains unchanged: to preserve these historic data records, provide indexing for guided retrieval, and make this valuable resource available to scientists for their research. After the designated archive data has been scanned, digitized, and reviewed, a relational database will be created that in-

Figure 6. Research vessel *John R. Manning*, USFWS, Bureau of Commercial Fisheries photo.

tegrates these archived survey records with the existing 1975-present time series and will ultimately be available on the AFSC web site.

By Beverly Malley and Robert Foy

FISHERIES BEHAVORIAL ECOLOGY PROGRAM - NEWPORT LABORATORY

Swimming Behavior of Pacific Cod and Walleye Pollock in a Simulated Trawl: Effect of Current Speed and Fatigue

Behavior is an important and complex factor in fish capture by trawls. Fish react to approaching trawls by escaping or herding into the trawl mouth where they continue to swim forward at the towing speed. When they become fatigued, fish turn and swim back into the trawl, with smaller (weaker) fish turning back sooner than larger fish. When fatigued fish move back into the body of the trawl and before final capture in the codend, they can encounter gradients of current speed that are slower than the towing speed as well as possible escape routes associated with net structure.

Trawls are often engineered to include bycatch reduction devices (BRDs), which facilitate the escape of nontarget species or sublegal-size fish. Escape can involve both passive sorting and active swimming out of the trawl. Towing speed and fish fatigue can control swimming behavior in the trawl mouth. However, little is known about the effects of current speed and fatigue on swimming further inside the trawl and how they may affect escape or retention. To design more effective trawl BRDs, probable effects of these variables on swimming behavior in the trawl must be determined.

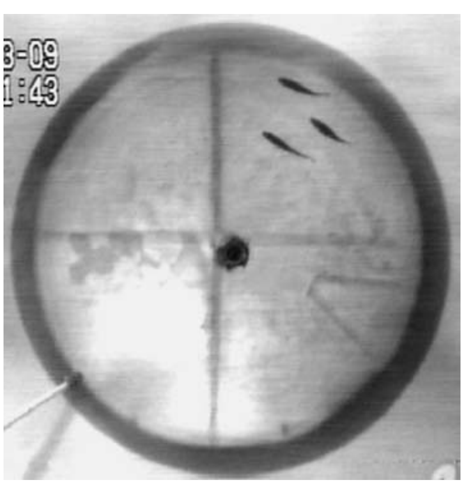
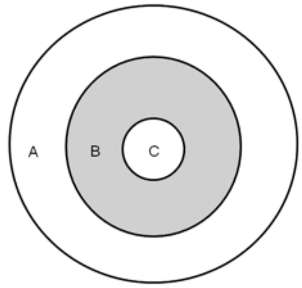


Figure 7. Frame from video of three Pacific cod (mean length = 24 cm) swimming in a circular flume (200 cm diameter).



Zone speed (cm s^{-1})	Flow into tank (l min^{-1}) 38	57	76
A	21(3)	27(3)	42(7)
B	12(3)	14(1)	24(1)
C	15(1)	21(2)	21(3)

Figure 8. Diagram of current speed zones in the circular flume. Sea water flowed into the flume at 38, 57, 76 l min^{-1} and produced mean (one standard deviation) current speeds (cm s^{-1}) in zones A, B, and C.

A circular flume (200-cm diameter, 25-cm depth) (Fig. 7) was constructed to test whether swimming behavior of Pacific cod (21-38 cm total length) and walleye pollock (31-37 cm total length) changed in response to current speed and fatigue. Seawater was introduced into the flume parallel to the tank wall and drained through a center standpipe to create continuous circular currents. The flume simulated current speeds and confinement found in posterior sections of trawls, where fish can accumulate and eventually escape through BRDs or move into the codend. In the circular flume, fish could chose between zones of faster or slower current speed (Fig. 8). Swimming in the flume was tested with current absent and three maximum current conditions (21, 27, and 42 cm s^{-1}). In an experimental trial, either control fish or fish fatigued to standard condition by chasing with nets were introduced into the flume. Here their swimming behavior was sampled over a period of 6 hours by frequency of tail beats, duration in the faster current zone and the slower current zone, and duration of stationary swimming, upstream swimming, and downstream swimming. Trials were performed in light and dark at 9.0°C and in light at 3.0°C to include a range of conditions found during trawl fishing. Groups of three fish were tested together in 128 experimental trials.

Pacific cod and walleye pollock made swimming choices readily in the circular flume. The most obvious effects on swimming behavior were associated with increased current speed, which resulted in increased swimming speed (frequency of tail beats) and increased duration of stationary swimming (Fig. 9). Fatigue had less of an effect on swimming behavior and resulted in decreased tail beat frequency, decreased duration in the faster current zone, and increased duration of stationary swimming, when compared to control fish (Fig. 9).

This study showed that prediction of swimming behavior in trawls is probably a complex function of current speed and fatigue. Bycatch reduction devices often modify current speeds in a trawl. The ability for fish to actively choose swimming behavior according to current speed and internal state (fatigue) supports previous field observations that BRDs can actively guide fish through a trawl to escape. Future research with the aim of increasing effectiveness of trawl BRD designs and prediction of fish escape should characterize current speeds throughout the trawl and test the roles of current speed and fatigue in controlling fish swimming behavior in actual fishing operations.

By Michael W. Davis

RECRUITMENT PROCESSES PROGRAM (FOCI)

Molecular Genetic Approaches for Species Identification

Mike Canino and Troy Buckley have been awarded a North Pacific Research Board (NPRB) grant to develop rapid, accurate, DNA-based identification methods for fish larvae and dietary components, with particular emphasis on taxonomic groups where traditional approaches are difficult, time consuming, and fail to identify to the species level. Routine application of these powerful molecular genetic methods in research conducted at the AFSC will allow for more accurate, timely, and cost-efficient species identification. Accurate identification of life history stages of marine fishes is central to understanding their distribution and abundance. Conventional taxonomic approaches have been successfully used for ichthyoplankton identification by Recruitment Processes Program scientists

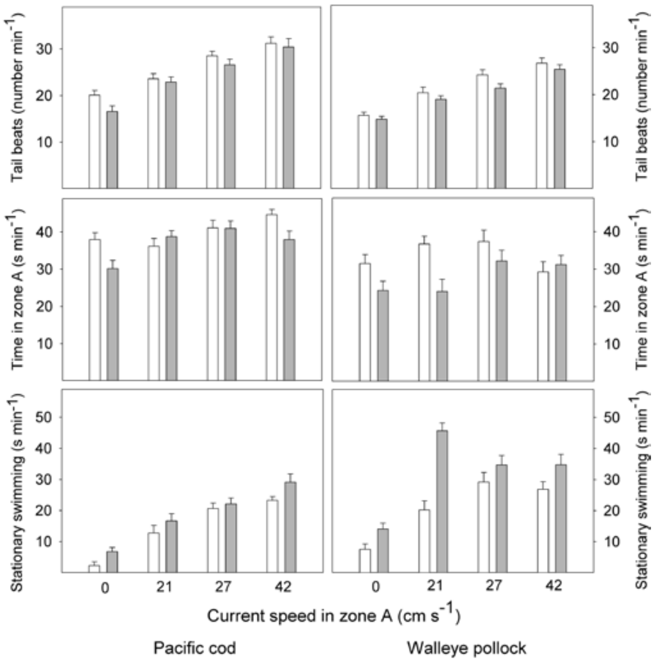


Figure 9. The effects of current strength and fatigue on Pacific cod (1+ and 2+ year) and walleye pollock (2+ and 3+ year) swimming behavior in light and dark at 9°C and light at 3°C. Control (white bar) and fatigued (shaded bar) fish swam for 6 hours in gradients of current, indicated by speed cm s^{-1}) in zone A of the circular flume. Mean values (+ one standard error) were reported for frequency of tail beats (number min^{-1}), duration in the faster current zone A (s min^{-1}), and stationary swimming (s min^{-1}).

for many years. However, diagnostic characters for eggs or larvae in some species have not been determined, making it impossible to accurately identify them below the genus, and sometimes family level.

AFSC scientists Mike Canino and Ingrid Spies have developed molecular genetic techniques that utilize fixed nucleotide differences in the mitochondrial DNA (mtDNA) genome for species identification. A restriction length fragment polymorphism (RFLP) protocol of the mtDNA cytochrome oxidase subunit I (COI) region was developed to identify eggs and larvae of Arrowtooth flounder, *Atheresthes stomias,* and Kamchatka flounder, *A. evermanni*, and was used in the NPRB-cofunded Bering Sea Integrated Ecosystem Research Program (BSIERP) to identify larvae of these two species at sea. The RFLP technique was successful in identifying the life history stages of these two species at sea. Tissue requirements for the assay were minimal (one eyeball per larva), allowing us to sort larvae to species for more rigorous taxonomic comparisons, descriptions, and illustrations.

By Mike Canino

Bering Sea Integrated Ecosystem Research Program (BSIERP) Spring Cruise

The Bering Sea Integrated Ecosystem Research Program (BSIERP) spring cruise was conducted 7-20 May aboard the NOAA ship *Oscar Dyson* in the Bering Sea to examine the interactions among climate, weather, and recruitment of fishes in the eastern Bering Sea. Ichthyoplankton and zooplankton sampling was conducted in the waters along the eastern Aleutian Islands chain, the Alaska Peninsula, and the Pribilof Islands (Fig. 10) in order to examine horizontal and vertical distribution of larval walleye pollock, Pacific cod, and arrowtooth flounder as well as the abundance and distribution of their plankton prey, and to perform genetic discrimination of *Atheresthes* spp. larvae at sea using molecular techniques (see previous article by Mike Canino).

The cruise represents collaboration between NPRB/BSIERP and NOAA's North Pacific Climate Regimes and Ecosystem Productivity program. Eighty-one stations were sampled for ichthyo- and zooplankton abundance using a bongo net array and a neuston net (505 µm mesh). The contents of one of each of the bongo nets and the neuston net were immediately preserved in sodium borate-buffered formalin to be sorted and identified at a later date. The contents of the remaining 60-cm bongo net were sorted live for fish larvae.

Sampling occurred along the slope between Bering and Pribilof Canyons, and approximately two dozen *Atheresthes* spp. larvae were collected. Catches of walleye pollock eggs in the Pribilof Island vicinity were high, particularly in the surface neuston tows. Catches of walleye pollock larvae, however, were relatively low compared to other years. Water temperatures were very cold (<1°C), which may have influenced the abundance of larvae, either by affecting the location or timing of spawning by adults. In total, only 25 walleye pollock larvae were collected at 15 stations around the islands, and no Pacific cod were encountered. Two stations in the Pribilof Islands were sampled for vertical distribution of fish eggs and larvae with the multiple opening/closing net and environmental sensing system (MOCNESS) (505 µm mesh).

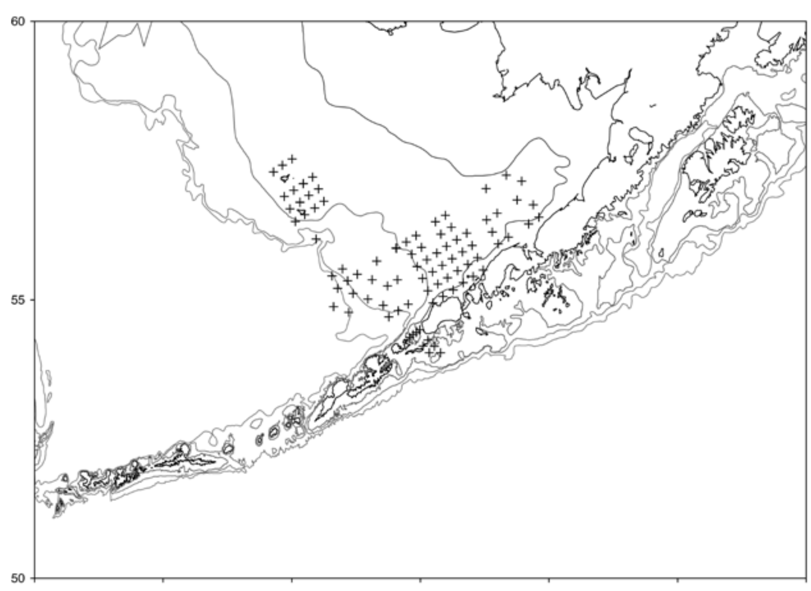


Figure 10. Map of eastern Bering Sea and Aleutian Islands showing station locations of the BSIERP May 2009 spring cruise.

Figure 11. Kenric Osgood deploying a drifter aboard the *Oscar Dyson* during the BSERP spring cruise .

Sea ice was present over the middle shelf during the cruise and is further evidence of the very cold conditions over the middle and outer shelves this past May. Plankton sampling along the Alaska Peninsula revealed very few larvae of any fish species, and water temperatures were also low (-1.5°C). Only 25 walleye pollock and 2 cod larvae were collected at 46 stations along the Alaska Peninsula. Typically catches of larvae are 1-2 orders of magnitudes higher (10–100X) in these geographic locations.

Sampling also occurred across Unimak Pass and over Bering Canyon. Three satellite-tracked drifters were released during this cruise (Fig. 11), the first over the slope, the second between St. George and St. Paul Islands, and the third along the Alaska Peninsula. Drifter tracks can be viewed on the web site of our collaborators at NOAA's Pacific Marine Environmental Laboratory (www.ecofoci.noaa.gov/drifters/efoci_drifterData.shtml). A cruise in July on the research vessel *Knorr* will use the drifter data to locate the fish contained in the spring patches and conduct additional sampling for the NPRB/BSIERP.

Of the 47 *Atheresthes* spp. larvae collected, we were able to genetically identify 41 individuals to species while at sea. Catches at the northern stations (between the Bering and Pribilof Canyons and in the Pribilof Islands) tended to have more Kamchatka flounder than Arrowtooth flounder, while catches at the southern stations (Unimak Pass and Bering Canyon) tended to have more Arrowtooth than Kamchatka flounder.

By Tracey Smart

Resource Ecology & Fisheries Management (REFM) Division

RESOURCE ECOLOGY & ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

During the second quarter of 2009, the AFSC's summer groundfish trawl surveys began in the eastern Bering Sea and the Gulf of Alaska. Resource Ecology & Ecosystem Modeling (REEM) Program staff collected stomach samples and analyzed stomach contents at sea for continued monitoring of predatory impacts on commercially important species and for food web energy flow analyses. In addition, stomach and tissue samples were collected for various ongoing essential fish habitat (EFH), NPRB, and BSIERP studies. Summaries of the number of samples collected and analyzed at sea during these groundfish surveys will be reported next quarter after the completion of the surveys. Laboratory analysis of the stomach contents of 709 walleye pollock was completed during the second quarter of 2009. In total, 5,640 records were added to the REEM food habits database.

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

Ecosystem Modeling and Assessment

Sarah Gaichas attended and co-organized the symposium "Conservation in Working Seascapes: Bridging the Gap Between Fishery Management and Biodiversity Conservation" at the International Marine Conservation Congress, a meeting sponsored by the Society for Conservation Biology's Marine Section held in Washington, D.C., on 19-24 May 2009. The purpose of the international meeting was to bring conservation and fishery scientists, managers, policymakers, and the public together to "put conservation science into practice" with respect to ecosystem-based management and global climate change, in particular to jointly address fishery and biodiversity conservation objectives. Dr. Gaichas' symposium was well attended and generated considerable discussion among the audience, the invited speakers, and the organizers. A summary publication is in preparation as a result of this symposium.

By Sarah Gaichas

Ecosystem Modeling

REEM modelers hosted a workshop of the NPRB's BSIERP Vertical Integrated Modeling Project in Seattle, on 1-3 June 2009. The workshop focused on continued development of the Forage and Euphausiid Abundance in Space and Time (FEAST) model, a 3-D model of the Bering Sea on a 10-km resolution, which will model the coupling between physics, plankton, forage fish, and predatory fish; the coupling between fish and plankton is bidirectional and includes feedback between these components. In the workshop, participants were able to complete a preliminary 1-dimensional (depth over time) version of the fully-coupled model and produce results comparing the relative growth and consumption of fish in a cold year (1999) versus a warm year (2004). A schedule and milestones for the development of the 3-D version of the model over the next 6 months was finalized. The milestones include performing comparative studies between model results and field observations that were conducted as part of the field component of BSIERP. Results of this workshop were presented at the annual meeting of the Resource Modeling Association and at the third international Global Ecosystems (GLOBEC) meeting in late June.

By Kerim Aydin and Ivonne Ortiz

Ecosystem Ecology

REEM researchers completed a 2-year project funded by the NPRB to investigate the age, growth, maturity, reproductive biology, and diet of five sculpin species: plain sculpin (*Myoxocephalus jaok)*, great sculpin (*M. polyacanthocephalus*, (warty

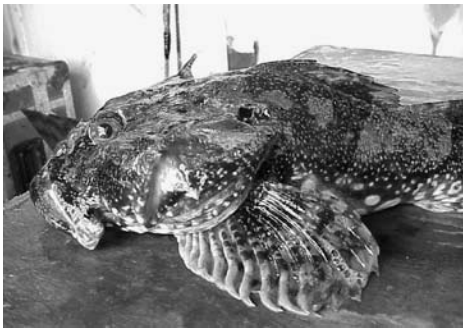


Figure 1. Pictured above, AFSC scientist Todd TenBrink conducts analysis of stomach specimens from yellow Irish lord. Four other sculpin species studied are pictured clockwise beginning at top left: bigmouth sculpin, plain sculpin, warty sculpin, and great sculpin.

sculpin) *M. verrucosus,* yellow Irish lord (*Hemilepidotus jordani*), and bigmouth sculpin (*Hemitripterus bolini*) (Fig. 1). These species contribute approximately 95% of the sculpin biomass within the Bering Sea/Aleutian Islands (BSAI) region. Sculpins occupy depths from nearshore sand and mud bottom waters at 20 m (plain sculpin) to below 1,000 m (darkfin sculpin, *Malacocottus zonurus*) along broad sloping and steep canyon areas. Size ranges observed for sculpins are less than 10 cm found in *Artediellus* to 80 cm for the great sculpin. Biomass estimates for the BSAI region have exceeded 200,000 metric tons (t). Although sculpins are most common along the eastern Bering Sea continental shelf, unique assemblages appear to be present within the shelf and slope areas of the eastern Bering Sea and the Aleutian Islands. Because of their abundance, sculpins are an ecologically important component in the eastern Bering Sea with some species feeding heavily on commercially caught snow and Tanner crabs, (*Chionoecetes* spp.) and juvenile pollock (*Theragra chalcogramma*).

By Kerim Aydin and Todd TenBrink

Seabird Coordinated Studies

A working session to provide guidance on estimating the bycatch of rare-event species, particularly seabirds and marine mammals , was convened at the AFSC on 22 June 2009. Participants included representatives from the AFSC the NMFS Alaska Regional Office; the Northwest, Pacific Islands, Southwest, and Northeast Fisheries Science Centers; and the University of Washington. The day's focus was to advise the AFSC on how to provide annual estimates of bird and mammal bycatch. Discussions noted mandated reporting requirements and general needs of end-users. Presentations were provided on coverage and observer sampling methods, the Alaska Region Catch Accounting System, and current bycatch estimation and modeling efforts in the Pacific Islands and Northeast Atlantic areas.

Participants noted that there was a strong dichotomy between an automated annual system where one would use ratio estimators, versus a more sophisticated system that would require much more analysis and examination of the data with respect to frequency of observations of no seabird or marine mammal bycatch. Having an estimation procedure that is well documented and repeatable was noted as a priority.

A report is being developed that will describe the day's efforts in more detail and will provide a list of recommendations. Generally, the AFSC plans to work with the Alaska Region's Catch Accounting System to support the annual production of seabird bycatch estimates while also looking into longer-term comparative modeling exercises to evaluate the effectiveness of this ratio-estimator based approach.

By Shannon Fitzgerald

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Multi-attribute Utility Function Approach to Developing Socio-economic Indicators for Fisheries

Ecosystem-based fisheries management requires a holistic assessment of the status of fisheries by integrating fishery ecosystem indicators for several major objectives such as sustainability, biodiversity, habitat quality, and socio-economic status. Scientists have already paid much attention to the first three objectives (i.e., sustainability, biodiversity, and habitat quality) and to the development of their indicators; relatively less attention has been paid to the fourth objective, socio-economic status and the development of its indicators. In addition, the socio-economic indicators developed so far are not firmly based on economic theory.

In this project, a multi-attribute utility function (MAUF) approach will be used to develop socio-economic indicators. In doing so, important economic concepts in utility function theory, such as preferential independence and utility independence, will be used to estimate the utility functions of various interest groups. Specifically, the project will 1) identify a suite of attributes (or indicators) describing the socio-economic status of fisheries; 2) examine the availability of the data for the attributes; 3) identify proxy data for the attributes for which the data do not exist; 4) elicit preferences from diverse interest groups and estimate individual utility functions for the groups; 5) integrate the individual utility functions by examining the value trade-offs to estimate an integrated utility function or social welfare function; 6) standardize the utilities to develop socio-economic indicators; and 7) integrate the socio-economic indicators with non-socio-economic indicators such as those to develop holistic ecosystem indices.

By Chang Seung

Data Collection from Alaska Communities

Economics & Social Sciences Research (ESSR) Program staff and contractors partnered with the NPFMC staff and University of Alaska Sea Grant staff to complete initial preparations to conduct an annual survey to collect community-level data from Alaskan communities. The foundational work for the survey was completed by the Communities Data Subcommittee of the Comprehensive Data Collection Committee (appointed by the Council). The information gathered in this survey will improve the commercial fisheries data available for communities involved in North Pacific fisheries, using the community as the unit of reporting and analysis. In addition to providing needed systematic annual data for socioeconomic impact assessments, the development of the survey is partly in response to long-standing requests from communities for the consideration of this type of data. The first year of the survey has been funded as a pilot project by NOAA, and future funding will likely depend on the success (and response rate) of the pilot year of the survey. Preliminary survey topics include a list of local fishing related businesses (and amount of local sales tax collected from each), fish tax information by community (and percent of city budget it constitutes), number of slips in harbor and trends in types of vessels, and a list of the names of vessels based in a community.

Surveys will be mailed to the 136 communities profiled in the 2005 NOAA Technical Memorandum NMFS-AFSC-160, "Community Profiles for North Pacific Fisheries – Alaska." These communities were selected for their participation in commercial fishing using a variety of commercial indicators. The surveys will be filled out by either an elected official or the community harbormaster. Training will be provided beforehand for community members asked to complete the survey. Follow-up visits and calls to nonresponding communities will be completed by project partners, including local and regional organizations. The survey will be developed this year and mailed in 2010. This data collection effort is a chance for communities to include information they have desired fisheries managers take into account in impact assessments but has not previously been available at the community level.

By Christina Package and Jennifer Sepez

NPFMC Takes Action to Limit Chinook Salmon Bycatch in the Bering Sea Pollock Fishery

At its April meeting, the NPFMC passed Amendment 91 to the Bering Sea Aleutian Islands (BSAI) Fisheries Management Plan, addressing the bycatch of Chinook salmon. AFSC scientists contributed to the development of alternatives considered and the analysis performed for the environmental impact statement reviewed for the amendment. The action establishes an upper limit (hard cap) of 60,000 Chinook salmon caught per year for the Bering Sea pollock fishery, with the additional requirement that Chinook bycatch be below 47,591 in all but 2 years in any 7-year period.

The bycatch quota will be allocated to sectors of the fleet proportional to both their pollock allocation and historic bycatch. The bycatch quota will then be allocated by cooperatives to individual vessels and will be transferable across the fleet and thus improve economic efficiency. The bycatch limits are scheduled to become effective in 2011. The amendment will require 100% observer coverage for all vessels in the pollock fishery, which will affect vessels in the 60-125 ft length category, which are currently required to have observers for 30% of their fishing days.

Limiting total Chinook salmon bycatch is expected to reduce the pollock fishery's impact on the number of Chinook returning to rivers. However, in periods of low salmon abundance a hard cap may be less effective since reaching the limit would be unlikely, although conserving bycatch may be most important at this time. For this reason, the Council explicitly required that vessel-level incentives to avoid bycatch be in place at all levels of abundance (the absence of such incentives will lead to a more restrictive hard cap). Incentive plans were developed by industry and refined with input from the Council's Scientific and Statistical Committee and AFSC economists. These plans will require further changes because the Council's approved motion includes a performance standard for vessels participating in an incentive plan agreement (IPA). IPA participants will be required to demonstrate to NMFS that their incentive plan will be compatible with the Council's motion, but the form of these plans and subsequent accountability measures are presently uncertain.

By Alan Haynie and Jim Ianelli

Chinook Salmon Bycatch Economic Data Collection Evaluation

After the NPFMC took action in April to limit Chinook salmon bycatch by the pollock fishery, ESSR Program economists wrote a discussion paper on options for expanded economic data collection to better evaluate the impacts of the NPFMC's April action. The discussion paper presents a range of expanded data collection options and discusses how expanded data collection would enable more thorough analysis of how the Council's April action impacts the pollock fishery and reduces Chinook salmon bycatch. The paper was presented to the Council's socioeconomic data collection committee and at the June Council meeting.

At the June meeting, the NPFMC selected a group of options for preliminary analysis, which will be completed prior to its October meeting. Key elements of data collection under consideration are 1) information on salmon and pollock quota transactions, 2) improved roe quality and quantity data, 3) vessel travel cost information, and 4) daily operations costs. If collected, these data will be utilized to evaluate how difficult it is for the pollock fishery to comply with the hard cap and to assess the effectiveness of additional bycatch reduction incentive plans that may be developed by industry.

ESSR economists currently are developing draft surveys for data collection and to help evaluate the alternatives under consideration by the Council. Preliminary analysis will be completed for the October Council meeting and final action is expected by December 2009 to enable the data collection to be in place by 2011, when new Chinook salmon bycatch regulations will go in place for the pollock fishery.

By Alan Haynie

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

Cooperative Workshop on Ocean Acidification and Marine Protected Areas

The AFSC hosted a workshop between NMFS and the Institute of Marine Research (IMR, Norway) on 15-17 April 2009. The workshop was intended to bring together scientists from the two organizations to increase the effectiveness of cumulative research efforts by NMFS and IMR. Discussions focused on 1) understanding the implications of ocean acidification to marine ecosystems, 2) sharing experiences with establishing and evaluating the effectiveness of marine protected areas (MPAs), and 3) developing joint projects for evaluating tools as part of a future management toolbox. The workshop was organized by AFSC Deputy Science Director Bill Karp, Bernard Megrey (RACE Division), and Susanne McDermott (REFM Division). Twenty-seven scientists participated in the workshop; 21 from the United States and 6 from Norway. The workshop started with presentations from NMFS and IMR on the two topics. Then the participants split into two groups for more in-depth discussion on ocean acidification and MPAs.

The Ocean Acidification group was led by Tom Hurst (AFSC/NMFS) and Knut Yngve Børsheim (IMR). The group recognized that though there are several other parallel research programs occurring in the United States and Europe, the group can play an important role in focusing research efforts related to ocean acidification on fishery species and high latitude fishery-dominated ecosystems. The group recommended organizing a special workshop within the next 12 months to 1) evaluate experimental setups, 2) exchange observations, and 3) evaluate early modeling reviews of system vulnerability.

The Marine Protected Area group was led by Susanne McDermott (AFSC/NMFS) and Erik Olsen (IMR). The initial discussion centered on establishing a clear definition of MPAs. The definition accepted defined MPAs as representing any marine area that receives permanent protection from any human impact that is greater than the protection provided in surrounding areas. The group also identified several potential projects for collaboration. A future workshop and ICES theme session at the 2010 ICES Science Conference in Nantes, France was proposed. Several topics were identified as priorities for the proposed workshop: 1) compare and contrast the implementation and governance of existing MPAs in the different regions/countries; 2) develop guidelines for establishing MPAs in heavily used ecosystems of the northern boreal continental shelf; and 3) identify currently available tools for MPA design and gaps in those tools such as larval dispersal tools, habitat mapping, gap analysis, life history studies, fishery impact mapping, and socioeconomic impact modeling. The group also planned to collaborate on projects comparing impacts and effects of existing MPAs in the different regions and countries.

By Susanne McDermott

Magnuson-Stevens Act Reauthorization: New Challenges for the AFSC

Across the United States, federal fishery scientists and managers are working hard to make sure that their fisheries comply with new rules passed by Congress. These new regulations originate in the 2006 reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), which is the principal law governing federal fisheries management. One of the major changes made during the reauthorization is a requirement that all target fisheries have annual catch limits (ACLs). This means that it is no longer sufficient to simply limit fishers' effort: there must be an absolute cap on the numbers or weight of a species caught each year in a particular region. In addition, the size of the cap must be based on maximum sustainable yield and other tenets of sustainable fishing theory. In many parts of the country this is posing serious challenges to regions that must overhaul their approach to fishery management. Alaska fisheries in federal waters are already managed using ACLs, so the AFSC and the NPFMC are having an easier time meeting the primary requirements of the new law.

There are additional aspects of the MSA reauthorization where it is less clear if the current Alaska system satisfies all conditions. New guidelines for complying with the MSA were published earlier this year by NMFS and contain many details related to the prevention of overfishing. These include ACL-related items such as buffers between the overfishing limit and the target level of catch, which are designed to account for scientific uncertainty, as well as accountability measures to ensure that ACLs are not exceeded. In addition, there are changes to the way that fishery management plans are structured. Fish stocks that are directly targeted or are caught incidentally in large enough quantities to pose conservation concerns are designated as "in the fishery" and require ACLs. Other stocks that are less vulnerable to fisheries but may still require monitoring or other management attention are designated "ecosystem components" (EC). There is no ACL requirement for EC species, but the fishery management councils can impose restrictions to limit EC bycatch. The AFSC and NPFMC are working to clarify these designations for Alaska fisheries.

The new guidelines also contain stricter language for the formation of stock complexes. Complexes are groups of two or more similar species that are managed as a single unit. This may occur because species are always caught together or because insufficient data are available to identify and calculate ACLs for individual species. The new rules tighten the requirements for how species can be combined, and the AFSC will be reviewing the existing complexes to ensure they comply with the MSA.

The coming year will see a great deal of activity as the AFSC and NPFMC strive to meet the 2011 deadline for compliance with the revised MSA. Although the new law creates additional policy and analytical burdens, it is designed to enhance the conservation of Alaska marine fish stocks.

By Olav Ormseth

AGE & GROWTH PROGRAM

Age and Growth Production Numbers

Estimated production numbers for the period from 1 January through 30 June 2009 include 14 species for a total of 15,237 specimens aged, with 3,767 test ages and 170 that were determined to be unageable.

Production Species	Specimens Aged
Atka mackerel	1,026
Bigmouth sculpin	40
Dusky rockfish	515
Flathead sole	470
Greenland turbot	240
Northern rock sole	263
Northern rockfish	1,083
Pacific cod	2,263
Pacific ocean perch	798
Quillback rockfish	52
Rex sole	1,589
Shortraker rockfish	278
Walleye pollock	6,143
Yellowfin sole	477

Ageing hard structures related to special research projects is also ongoing. These projects include continued efforts to establish and verify ageing criteria for rockfish, such as shortspine thornyhead, and forage species, such a capelin and eulachon; life history and growth characteristics of deepwater grenadiers and big skates; and ageing arctic cod. In addition, research is under way to develop new age validation tools using bomb radiocarbon (C-14) and trace elemental analysis and to understand fish growth in relation to environmental variability. Several of these special research initiatives involve collaborative efforts with other AFSC staff and external institutions.

By Tom Helser

Age Determination Manual Nearing Completion

The Age & Growth Program is putting the final touches on the manuscript "Age Determination Manual of the Alaska Fisheries Science Center Age and Growth Program," which is intended for the NOAA/NMFS Professional Paper series. This nearly 500- page document represents the culmination of many years of hard work and research by dedicated AFSC age readers and scientists who have collectively contributed to our understanding of the phenomena of fish age determination. The primary focus of the manual is to serve as a working document for age readers and age data users by describing historic and current age estimation practices. The manual also is intended as a resource for insight into descriptive statistics (bias, precision) useful to population modelers and also as a resource for understanding the A&G Program's investigations into state of the art age validation techniques and relationships between environmental factors and fish growth. The document is intended as a living document which will evolve with the advent of new technologies and ageing criteria.

By Tom Helser

Fish Age Validation with Radiocarbon from Atomic Bombs

The Age and Growth Program works to test and improve the accuracy of fish ages generated for stock assessments. Historically the program has used a number of methods for age validation studies, but in recent years bomb-produced radiocarbon (C-14) has been a method of choice.

During the Cold War era in the 1950s to 1960s, above-ground testing of atomic bombs led to a substantial increase in marine C-14. Any marine organism alive at that time incorporated bomb-produced C-14 in their calcified hard parts, providing a time stamp for age estimation. The bomb radiocarbon age validation method relies on fish of known age that were alive during the era of increasing C-14 and on measurements of C-14 in their otolith cores to create a "reference." The otolith core is material deposited in the first year of life. In age validation studies, C-14 in the otolith cores of "test" specimens is compared to the reference. If the increases in C-14 from the test and reference specimens are synchronous, the test specimens' posited birth years, based on otolith growth zone counts, are considered accurate.

The Age and Growth Program has recently used bomb-produced C-14 in a number of species to validate the accuracy of growth-zone-count ages. Age validation studies on Pacific ocean perch and Dover sole from the Gulf of Alaska (GOA) have been completed and published. Studies on three other species—yellowfin sole, northern rockfish, and Greenland halibut—are in various stages of completion.

A reference from the GOA used extensively for these studies is Pacific halibut (Fig. 2). For an example of this method, Figure 2 shows three test species in comparison to the reference: northern rockfish from the GOA, Dover sole from the GOA, and yellowfin sole from the eastern Bering Sea (EBS). Northern rockfish and Dover sole are examples where the test specimens are

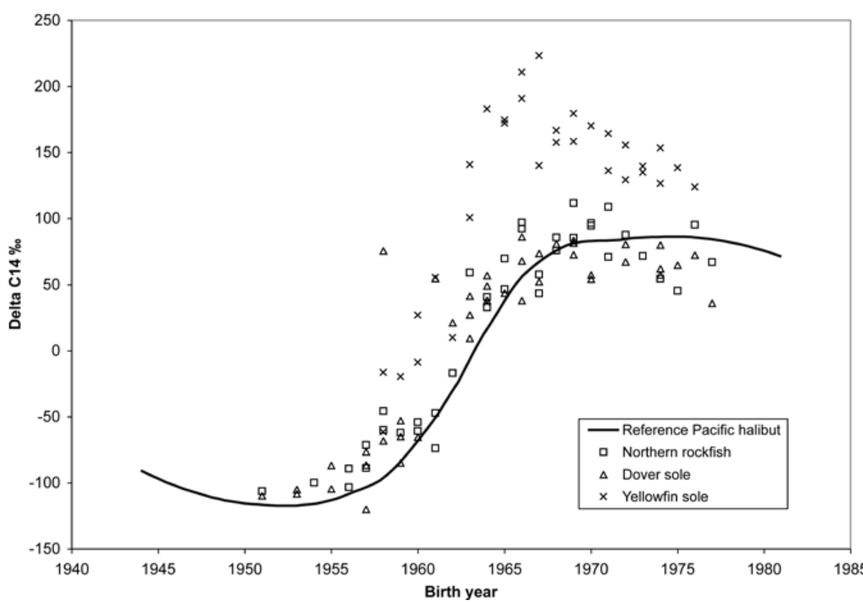


Figure 2. Results of bomb-produced radiocarbon (C-14) age validation studies. The reference is Pacific halibut (line is a LOESS smooth of measured C-14 representing 1944 to 1981). The test species displayed in comparison to the reference are northern rockfish, Dover sole, and yellowfin sole.

in phase with the Pacific halibut reference. For these two species, the appearance of a small bias where the measured test values of C-14 lie to the left of reference is expected due to larger core sizes that represented more than the first year of life. Therefore, northern rockfish and Dover sole age estimates were deemed accurate. The third test species used as an example in Figure 2 is yellowfin sole from the EBS. Yellowfin sole from the EBS have a much larger bias to the left of the GOA reference and have much higher levels of C-14. These dissimilarities are likely due to geographical differences in marine bomb-produced C-14 between the GOA and EBS and point out the need for area-specific C-14 references. In two other species, giant grenadier and shortraker rockfish, this age validation method was not successful, probably because their juvenile stages reside in deeper water than the reference Pacific halibut, and thus have a different C-14 uptake rate. The Age and Growth Program is continuing this area of age validation research in other species and is working to develop new references for areas such as the EBS.

By Craig Kastelle

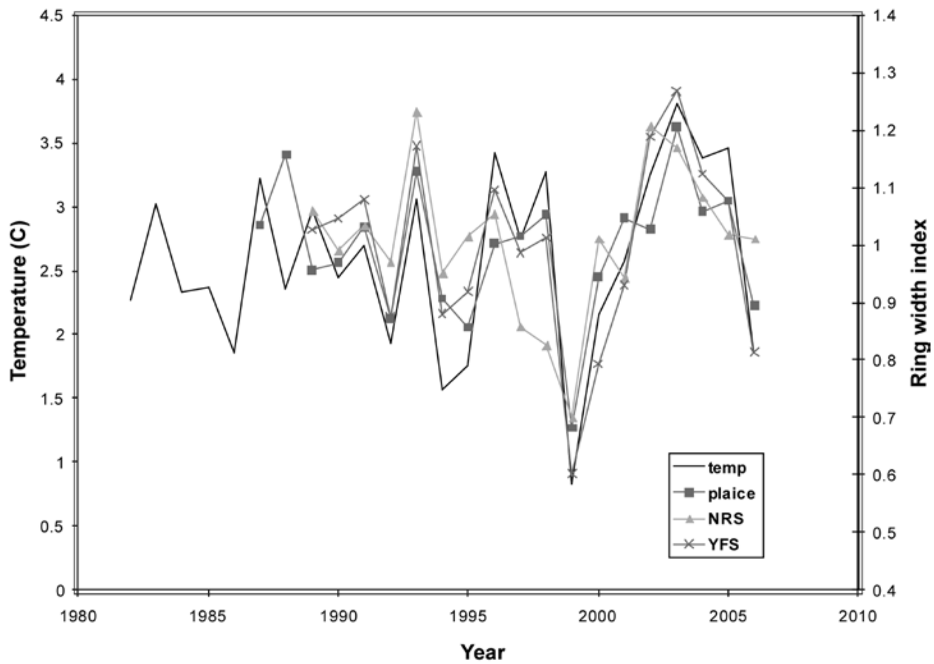


Figure 3. Comparison of summer bottom temperatures and otolith master chronologies of three species of Bering Sea flatfish: Alaska plaice, northern rock sole (NRS), and yellowfin sole (YFS).

Relationships Between Otolith Growth Increment Widths and Bottom Temperature for Three Bering Sea Flatfish Species

Fish growth is affected by environmental variables. In turn, fish otoliths are thought to provide a record of these variables through their link to somatic growth. To explore the effects of climate on fish growth, a dendrochronology (tree-ring science) study was undertaken in collaboration with Dr. Bryan Black (Hatfield Marine Science Center, Oregon State University) The dendrochronology technique of cross-dating was applied to fish otolith growth increments. Cross-dating is the process of assigning the correct calendar year to each growth increment and comparing relative growth increment time series, or chronologies, among specimens in a sample set. This technique can be used to evaluate synchrony in growth between individuals of a given species and among different species, and between growth increments and environmental indices.

Digital photographs of otolith cross sections were visually cross-dated to assign the correct calendar year to each growth increment. Growth increment widths were then measured using imaging software. Cross-dating was statistically verified using COFECHA software (International Tree-Ring Data Bank Program Library) to ensure that no growth increments were missed or incorrectly added. Growth declines associated with age were detrended by fitting each measurement time series to a negative exponential function. Detrended measurement time series were then averaged to obtain master chronologies, or ring-width index time series, for each species.

Master chronologies were developed for three species of Bering Sea flatfish: northern rock sole (*Lepidopsetta polyxystra*), yellowfin sole (*Limanda aspera*), and Alaska plaice (*Pleuronectes quadrituberculatus*). Otolith growth among individuals of a given species was found to be highly correlated (R = 0.59-0.66), as were the master chronologies among the three species (R = 0.71-0.90). The high degree of synchrony between chronologies is a corroboration of age estimates obtained from counting growth increments.

All three master chronologies were highly correlated with summer bottom temperatures (R = 0.59-0.90; Fig. 3) and sea surface temperatures (R = 0.71-0.85). Otolith ring width index was positively related to Bering Sea summer bottom temperatures for all three species (R^2 = 0.59-0.81).

Given the relationship between otolith size and body size, this study suggests that somatic growth is strongly influenced by environmental factors, either directly (metabolically) or indirectly (e.g., as a result of food availability), and occurs synchronously across species and broad spatial scales in the Bering Sea.

This work will be presented at the Fourth International Otolith Symposium in Monterey, California, in August 2009, and a paper is currently in preparation.

By Beth Matta

Age and Growth Educational Outreach

Age and Growth Program Staff continue to inspire budding young scientists with educational outreach activities. Chris Gburski and Chris Johnston, with assistance from Irina Benson, put on an "Age and Growth of Fishes" demonstration for the 2009 Summer NOAA Science Camp. Craig Kastelle presented a demonstration of marine life using fish otoliths and marine mammal bones at Cedar Wood Elementary School's annual "Day of Science."

By Tom Helser