AUKE BAY LABORATORIES (ABL)

Pacific Herring in Lynn Canal, Alaska: Are They a Discrete Population?

On 2 April 2007 the National Marine Fisheries Service (NMFS) received a petition from the Sierra Club to list Pacific herring (*Clupea pallasi*) in Lynn Canal, Alaska, as endangered or threatened under the U.S. Endangered Species Act (ESA). The petition identified the decline in Lynn Canal herring biomass and failure to recover as the principal symptoms (Fig. 1) and suggested that "ongoing destruction of spawning beds, degradation of water quality, and pollution associated with human developments now threaten the remaining spawning grounds." In response, a biological review team (BRT) was formed to review the status of these fish and determine if Lynn Canal herring are a distinct population segment (DPS) of Pacific herring as defined by the ESA. The BRT included personnel from the Alaska Fisheries Science Center, Northwest Fisheries Science Center, National Park Service, and NMFS Alaska Regional Office with data and advice provided by the Alaska Department of Fish and Game (ADF&G), the agency that manages Pacific herring in Alaska.

To be classified as a DPS under the ESA, a vertebrate population must fulfill two criteria: discreteness and significance. To be considered "distinct," a population or group of populations must be "discrete" (markedly separated) from other populations of the same taxon as a consequence of genetic, physical, physiological, ecological, or behavioral factors. If discrete, its biological and ecological significance to the taxon must then be considered. Assessment criteria include 1) persistence of the discrete population segment in an unusual or unique ecological setting, 2) evidence that loss of the discrete population segment would result in a significant gap in the taxon range, 3) evidence that the discrete population segment represents the only surviving natural occurrence of a taxon, or 4) evidence that the genetic characteristics of the discrete population segment differ markedly from genetic characteristics of other populations of the species.

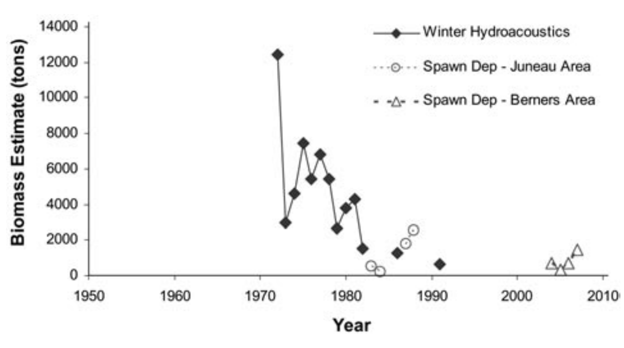


Figure 1. Historic biomass estimates for Lynn Canal herring based on a variety of assessment techniques. The time series provided by the petitioner began in 1971 and relied on hydroacoustics through the early 1980s and aerial surveys thereafter.

LYNN CANAL HERRING

The historic Lynn Canal spawning area, as defined by ADF&G, ranges from Berners Bay south to Taku Harbor and encompasses an area of about 950 km^2 (Fig. 2). The Lynn Canal Pacific herring stock was one of the larger populations in southeastern Alaska prior to 1983 (third in the 1930s) but declined through the 1970s and has been depressed since 1982. Studies by H.R. Carlson, who summarized earlier work, focused primarily on a subset of this region (16%). Spawning in Lynn Canal was previously distributed from Juneau (Auke Bay) north to Berners Bay; since 1990, however, most spawning has been concentrated in Berners Bay north of Cascade Point and from Point Bridget south to Mab Island. Summer feeding areas are on the west side of Douglas Island with most fish found at depths between 5 and 37 m, whereas in winter, herring move into deeper waters and remain in dense concentrations near the bottom (73 to 110 m). Herring biomass in Lynn Canal peaks in winter (December to February) and decreases sharply thereafter. The fish are not stationary during this period; schools form in the Benjamin Island area in November, then shift south toward Amalga Trench. Because marine mammals are concurrently confined to these areas, herring are also likely confined primarily to these areas. Herring have utilized Fritz Cove in winter for three decades but abundance in Auke Bay has declined, offset by an increase near Benjamin Island and in the Amalga Trench. The submarine gully in this area is apparently critical winter habitat for the Lynn Canal herring stock and presumably offers benefits by reducing energy expenditure (sheltering from tidal currents) and predation (lower light levels may reduce predation by visual feeders).

HERRING IN SOUTHEASTERN ALASKA

A variety of parameters were examined among all southeastern Alaska herring stocks to determine how Lynn Canal herring may or may not differ and how Lynn Canal herring habitat may or may not differ. These parameters included habitat utilization, age structure, biomass change, genetics, spawn timing, recruitment synchrony, size at age, meristics (vertebrae number), and fish movement. Examined habitat characteristics included shore type, habitat classifications, and macroalgae cover.

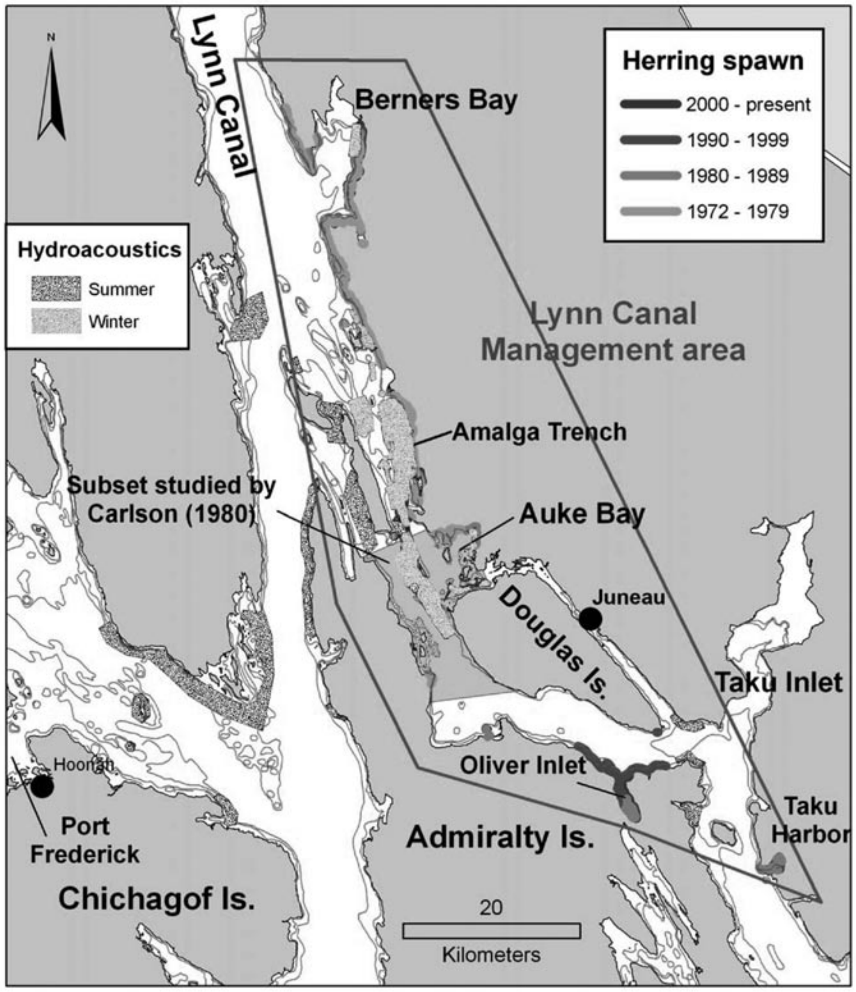


Figure 2. Lynn Canal Management area as defined by the ADF&G and the subset studied by Carlson (1980). Nonspawning herring located by acoustic survey are indicated in dark stipple (summer) or light stipple (winter). Spawning is indicated by grey tone by decade; however, these lines often overlap and not all temporal detail is visible.

Marine habitat in southeastern Alaska is variable, yet Pacific herring essentially occupy all of it. Organic sediment and semiprotected, partially mobile substrate are the most common shore type and habitat class among all areas. Marine waters of southeastern Alaska are characterized by an inshore-offshore salinity gradient and a north-south temperature gradient. Inside waters are more estuarine, more protected from wave action, and have more extreme seasonal fluctuations in temperature and salinity than outside waters. Herring are captured in essentially all areas of southeastern Alaska; occasional capture failures are likely due to insufficient sampling, not an absence of herring. Eelgrass meadows, kelp communities, sand-gravel beaches, and bedrock outcrops comprise a continuum of habitat types available to herring throughout southeastern Alaska.

Habitat in Lynn Canal is not markedly different from habitat elsewhere in southeastern Alaska. The percent shoreline extent of kelps (canopy and understory) and eelgrass are less in Lynn Canal than in all other areas, but this does not appear to limit spawning or modify herring behavior; herring are euryhaline, eurythermal, and spawn on a wide variety of substrates. Measured temperatures and salinities are not unique, and the area is not isolated by features that impede water exchange or act as migration barriers.

Based on available evidence, the biological review team concluded that Lynn Canal herring are not markedly different from other stocks in southeastern Alaska. In brief, there are no known genetic differences between Lynn Canal stock and other herring stocks in southeastern Alaska, although the team recognized that available genetic data were limited by methodology and geographic detail. Spawn timing in Lynn Canal does not differ from the timing in other northern southeastern Alaska stocks; rather, spawn timing partitions into an early southern group and a later northern group consistent with the latitudinal spawning cline along the entire western coast of North America. Although Lynn Canal herring data are limited, large year class

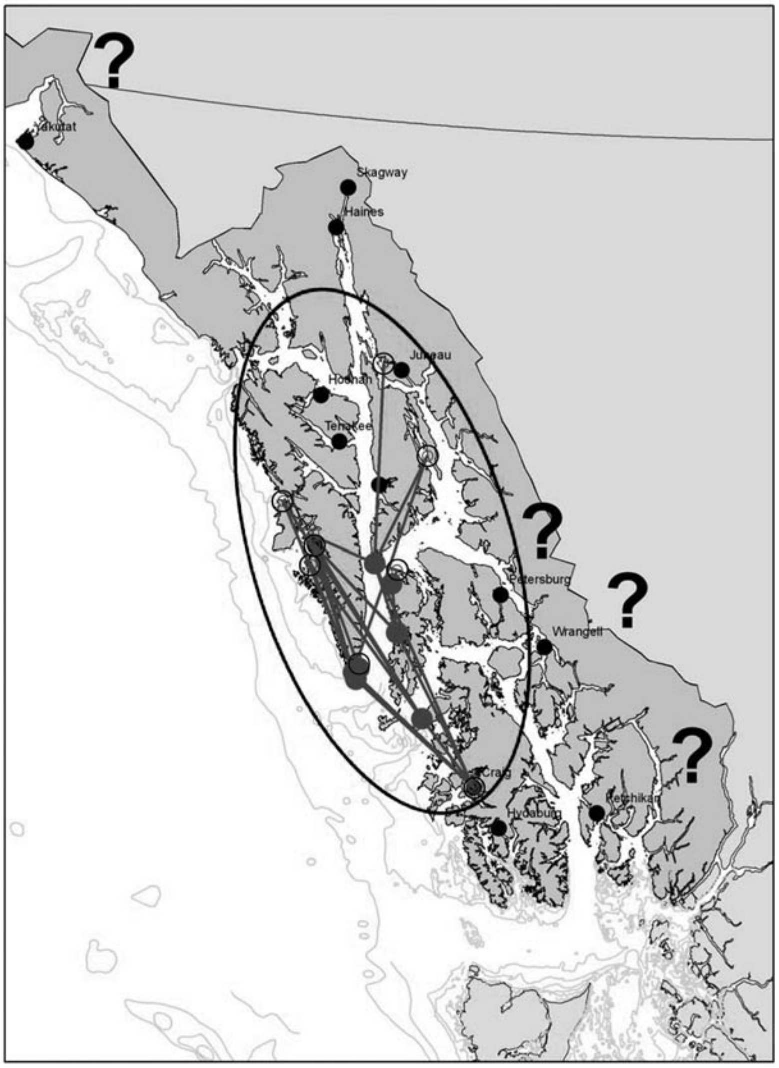


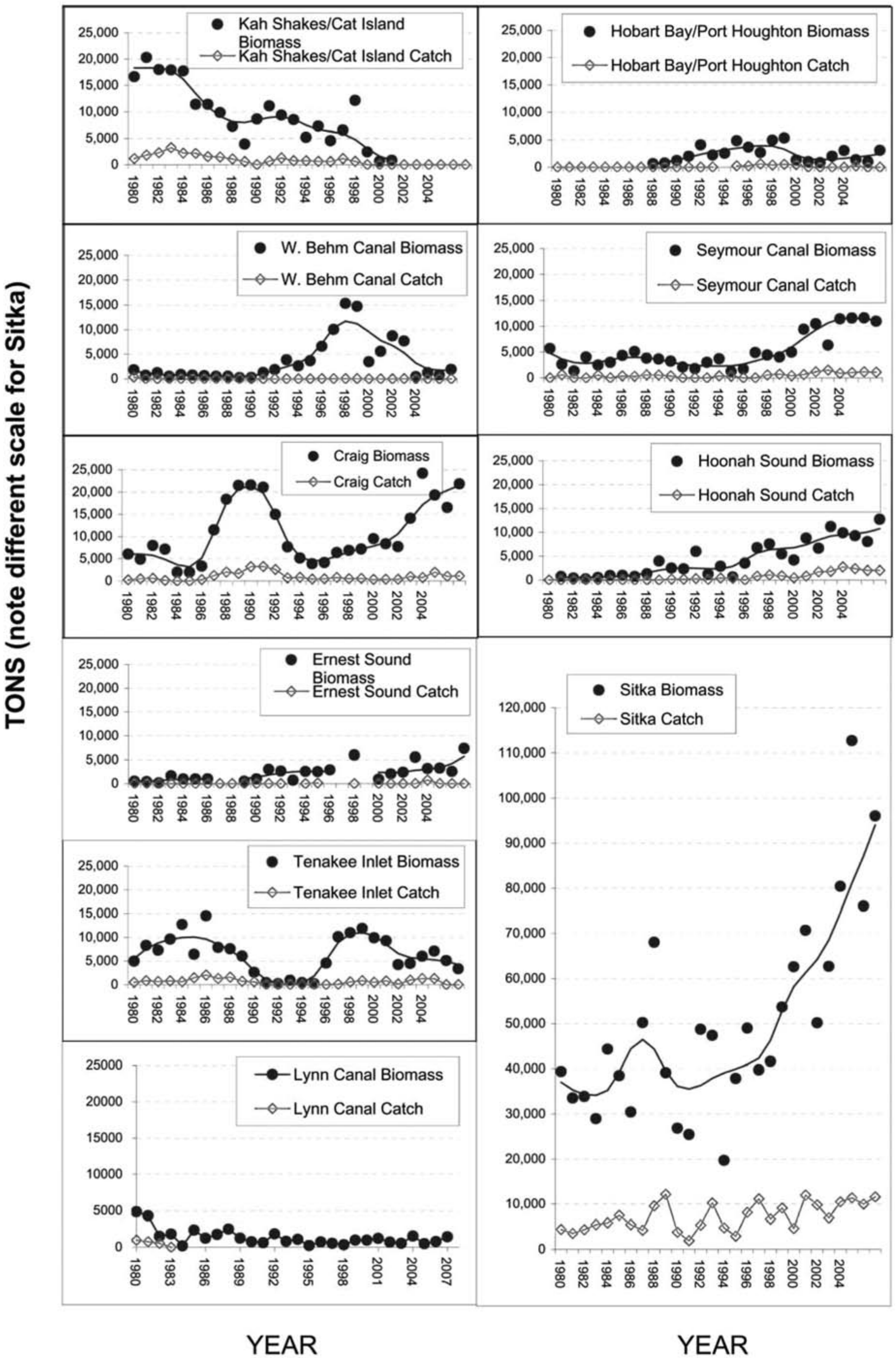
Figure 3. Pacific herring migration in southeastern Alaska, observed by tagging studies. Open symbols depict release sites; closed symbols depict capture sites. Question marks indicate missing or incomplete information. The circled area identifies the approximate area of known mixing and is 31,600 km^2 (water only); predicted herring spawning fidelity within an area this large is 100%.

occurrences are apparently synchronous with other southeastern Alaska stocks. Based on ADF&G data, individual fish growth rates are not significantly different among southeastern Alaska Pacific herring stocks (P = 0.577), consistent with conclusions drawn from several other datasets. Meristics does not provide clear separation within southeastern Alaska stocks. Herring from multiple locations throughout southeastern Alaska mix in a summer feeding area (Fig. 3); however, no tagging studies have been completed in southeastern Alaska to determine spawning fidelity. Herring occupy nearby waters adjacent to the Lynn Canal area, and these populations may be functionally continuous. Based on tagging studies in British Columbia, predicted herring spawning fidelity within an area the size of the Lynn Canal management area is about 40%, suggesting considerable exchange with surrounding stocks is plausible. Also based on British Columbia data, the average net yearly movement of herring is about 90 km, and herring can travel considerable distances in short periods of time; for example, ripe, prespawning herring moved 150 km in 6 days and spent fish moved 350 km in 16 days.

Human shoreline development cannot be definitively identified as a causal factor for the decline of the herring population in Lynn Canal or its failure to recover. Shoreline development, which presumably elevates the relative potential for contaminant discharge and physical habitat disruption, is greatest in the Lynn Canal management area (8%). However Sitka Sound is the second most developed area (6%) and is utilized by the largest and increasing herring biomass in southeastern Alaska. Although the biological review team cannot eliminate the possibility that shoreline development reduces stock biomass wherever it occurs, they suggest the 2% difference in human development between Lynn Canal and Sitka habitats does not explain the very different population loss and growth trajectories at the two locations.

Although the report concludes that Lynn Canal herring are not markedly different from other southeastern Alaska herring, the team recognizes there is evidence for discreteness. Lynn Canal has consistent spawning areas discontinuous with adjacent spawning areas. Repeat spawning in given areas suggests utilization by at least some of the same fish. In addition, herring are found throughout the year in Lynn Canal. Temporal changes in biomass are not synchronous with nearby stocks (Fig. 4). This suggests that herring do not randomly disperse into

Figure 4. (facing page) Total mature herring biomass (tons) and human harvest (tons) at major spawning locations in southeastern Alaska. Lynn Canal biomass and harvest are based on ADF&G estimates. Biomass is characterized with smoothed data.


TONS (note different scale for Sitka)
Kah Shakes/Cat Island Biomass
Kah Shakes/Cat Island Catch
Hobart Bay/Port Houghton Biomass
Hobart Bay/Port Houghton Catch
W. Behm Canal Biomass
W. Behm Canal Catch
Seymour Canal Biomass
Seymour Canal Catch
Craig Biomass
Craig Catch
Hoonah Sound Biomass
Hoonah Sound Catch
Ernest Sound Biomass
Ernest Sound Catch
Sitka Biomass
Sitka Catch
Tenakee Inlet Biomass
Tenakee Inlet Catch
Lynn Canal Biomass
Lynn Canal Catch
YEAR
YEAR

areas with lower population density; that is, there is no evidence that Lynn Canal herring are being repopulated (or successfully repopulated) by excesses from nearby, growing populations. Thus, persistence of depressed stock abundance is evidence of discreteness.

Even though not all BRT members agreed with the majority decision that Lynn Canal herring are not markedly discrete, no members perceived Lynn Canal herring to be significant with respect to the taxon (although all recognized the importance of herring in the local ecosystem). Thus, the consensus opinion was that even if Lynn Canal herring were discrete, the significance criterion precludes its definition as a distinct population segment.

The report concludes that the smallest defensible discrete population segment that includes Lynn Canal is southeastern Alaska. Although the team recognized the possibility that there may be subdivisions within southeastern Alaska, available biological data are either too incomplete or too similar to definitively separate herring populations within this region. The southern limit of the DPS, Dixon Entrance, is identified by genetic differences between herring in southeastern Alaska and those in British Columbia. Genetics did not provide a definitive northern separator, rather the northern border is defined by a physical barrier: open ocean beaches are inadequate as spawning and rearing habitat. The northern boundary is near Icy Point.

Southeastern Alaska meets the citeria for designation as a DPS under the ESA, as it is both discrete and significant to the taxon. It is a unique habitat, intermediate between warmer southern habitat along the eastern Pacific and cooler habitat to the north. The loss of a population this size would result in a large, significant gap in the range of the taxon; area involved exceeds normal territorial size of herring by more than a factor of 2 and the distance of southeastern Alaska from Cross Sound to Dixon Entrance (roughly 500 km) exceeds the presumptive exposed beach barrier distance between Prince William Sound and Yakutat (400 km). Genetic evidence suggests that southeastern Alaska stock is different from British Columbia stock but not different from nearby Gulf of Alaska stocks to the north and west. One study found evidence of genetic structure within Prince William Sound, raising the possibility a more detailed study with modern techniques may indicate differences between these stocks and southeastern Alaska stock. However, subsequent study demonstrated that DNA data provide no evidence of stable differentiation among Pacific herring populations within sea basins on spatial scales of up to approximately 700 km, rather temporal variation was dominant.

The biological review team based its decision on the best available science, yet recognizes that the science behind these decisions is imperfect. They also recognize that precautionary management of animals and ecosystems is a wise approach that goes beyond the language of the ESA. Precautionary management is the current stance of the ADF&G, the agency responsible for Pacific herring in Lynn Canal. The fishery has not been open since 1982. The information assembled will further enable the ADF&G to appropriately manage this stock, and it will enable Federal agencies responsible for the permitting of shoreline development to manage Lynn Canal herring in a precautionary manner.

by Mark Carls

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FISHERIES MONITORING & ANALYSIS (FMA) DIVISION

Ensuring The Quality of Data Collected By Observers: The Debriefing Process

Debriefer Marlon Concepcion and observer John Anderson review data.

The Fisheries Monitoring and Analysis (FMA) Division's North Pacific Groundfish Observer Program supplies data needed for management of the groundfish fisheries in the Bering Sea and Gulf of Alaska. Our success is dependent on the quality of the data collected by observers. A major focus of FMA is to ensure quality data are collected by observers using scientifically valid methods. While observer training prior to deployments ensures that methodologies are standardized, the quality and reliability of the data collected cannot be fully assessed by FMA until observers complete a debriefing with staff at the conclusion of deployments. In 2007, FMA staff conducted 610 post deployment debriefings reviewing information collected from over 50,000 hauls.

Debriefings are always in person, and this provides important face-to-face interactions between FMA staff and observers. Given the remote working environment in Alaska, the in-person debriefing contact is an opportunity to review the at-sea work in depth and discuss any unusual incidents or sightings at sea. Staff gain good knowledge of the observer's work performance and the observer receives feedback for future work.

Debriefing consists of five main components: 1) completion of an electronic survey for each vessel or processing plant assignment during the observer's deployment, 2) an interview with staff, 3) a thorough data check, 4) documentation of the observer's work and performance in a written evaluation, and 5) completion of a feedback questionnaire.

Completion of a survey systematically captures detailed descriptions of each deployment to a vessel or processing plant. Questions in the survey cover sampling methodologies, difficulties encountered during the cruise, potential violations, protected species interactions, and other details pertinent to the data collected. Once the survey is completed, observers submit their data and are scheduled for a staff interview.

During the interview, the observer's surveys are reviewed, and any necessary corrections or clarifications are completed. All data collected by the observer are reviewed for completeness, accuracy, and format, and all samples are submitted. The methodologies used are discussed to ensure our sampling protocols were followed. The interview is intended to be educational with staff providing feedback to the observer regarding work accomplished and suggestions for future deployments.

Although observer data are quality control checked throughout each deployment, it is at the debriefing where a final data check is completed and corrections are made. The data checking process is extensive. For example, we check for unlikely geographic positions, specimens recorded that are outside of the expected length or weight ranges, mismatches between different forms, and missing data entries. Staff work with the observer to resolve each error.

At the close of the debriefing, the observer receives a written evaluation of his/her work performance. This feedback to the observer is essential to future deployments, and we identify any future training needs.

Last, observers have an opportunity to complete a final questionnaire where they can give anonymous feedback to NMFS with suggestions for improvement. Managers periodically review this survey to assess the comments.

Debriefings are labor intensive and are essential to maintain high quality data for fisheries management. The debriefing process lasts from a few hours to several days, depending on the number of vessel or processing plant assignments, the completeness of the surveys, and the performance of the observer. Unfortunately, the debriefing workload comes in large surges as observers complete their field work. FMA shifts staff to assist in the surge workload while continuing to maintain a quality process.

By Allison Barns and Martin Loefflad

NATIONAL MARINE MAMMAL LABORATORY (NMML)

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

Gray Whale Counts in January 2008

The National Marine Mammal Laboratory (NMML) has been responsible for providing abundance estimates of gray whales (*Eschrichtius robustus*) most years since the mid-1960s. Counts used in these estimates have come from shore-based counts conducted at Granite Canyon in central California. However, starting in 2008, the gray whale census is being conducted by the Southwest Fisheries Science Center (SWFSC). Now NMML's role in the gray whale census is to assist in the transfer of information, document procedures, and provide parallel counts to compare the old counting protocol to the new methods used by the SWFSC. For example, NMML has maintained the basic technique of one observer searching alone for whales and writing the data by hand on a field form (Fig. 1). In contrast, the SWFSC operates with pairs of observers, with one observer dedicated to searching for whales while the other assists with the search and types the data into a computer (Fig. 2). The computer program shows the SWFSC observers where whale groups have been sighted and predicts where they should look for subsequent sightings of the same groups.

Throughout most of January, one to three NMML observers rotated through 3-hour watches, sitting in a small, wooden shed on the edge of a 22-m sea cliff. Meanwhile, from 2 January to 9 February, SWFSC observers rotated through 1.5-hour watches while conducting an independent effort in a nearby trailer. As in most recent years, observations through a fix-mounted, high-powered

Figure 1. The National Marine Mammal Laboratory conducts searches for gray whales using only one observer in a small shed.

Figure 2. The Southwest Fisheries Science Center conducts searches with two observers in a comfortable trailer.

(25X) binocular provided an index of the offshore distribution of whales within the observers' viewing range. The SWFSC will provide an abundance estimate, and both NMML and the SWFSC will conduct an analysis of how well matched the two sighting efforts were.

By David Rugh

Bowhead Whale Feeding Ecology Study

The National Marine Mammal Laboratory (NMML) received funds from the Department of the Interior's Minerals Management Service (MMS) for a 5-year $5,095,000 study of bowhead whale (*Balaena mysticetus*) feeding ecology, starting in 2007. This study focuses on late summer oceanography and prey densities relative to whale distribution over continental shelf waters within 100 miles north and east of Point Barrow, Alaska. Participating researchers from NOAA Cooperative Institutes are from the Woods Hole Oceanographic Institution, University of Rhode Island, University of Alaska–Fairbanks, University of Washington, and Oregon State University. Fieldwork is coordinated with the North Slope Borough, Alaska Eskimo Whaling Commission, Barrow Whaling Captains' Association, Alaska Department of Fish and Game, and MMS.

Aerial surveys and acoustic monitoring provide information on the spatial and temporal distribution of bowhead whales in the study area. Oceanographic sampling helps identify sources of zooplankton prey available to whales on the shelf and the association of this prey with physical characteristics (hydrography, currents) which may affect mechanisms of plankton aggregation. Prey distribution will be better understood by examining temporal and spatial scales of the hydrographic and velocity fields in the study area, particularly relative to frontal features. Results of this research program may help explain increased occurrences of bowheads feeding in the western Beaufort Sea (in U.S. waters), well west of the typical summer feeding aggregations in the Canadian Beaufort Sea. Increased understanding of bowhead behavior and distribution is needed to minimize potential impacts from petroleum development activities.

By David Rugh

POLAR ECOSYSTEMS PROGRAM

Comanagement Activities with Alaska Native Organizations

Polar Ecosystems Program (PEP) staff participated in the following comanagement activities with Alaska Native organizations:

- A workshop convened by the U.S. Marine Mammal Commission during February 2008 in Anchorage. The workshop included representatives of Alaska Native organizations, Federal and state agencies, and nongovernmental organizations. The purpose of the workshop was to review the accomplishments and challenges encountered since the 1994 amendments to the Marine Mammal Protection Act established the authority for the Federal government to enter into cooperative agreements with Alaska Native organizations for the comanagement of subsistence uses of marine mammals. The agenda for the 3-day workshop included discussions of harvest monitoring, traditional ecological knowledge, research, education, outreach, conflict resolution, structures of comanagement agreements, hunter representation, funding, capacity building, and many other topics relevant to comanagement. The Marine Mammal Commission will issue a report to Congress on the workshop findings and recommendations.

- A meeting of the North Slope Borough (NSB) Fish and Game Management Committee. The NSB is one of five regions represented on the Alaska Native Ice Seal Committee, with which NMFS has an agreement for comanagement of ice-associated seals and their subsistence use in Alaska. A presentation was given to introduce PEP research projects and to encourage participation of North Slope communities in the planning and implementation of a study on bearded seals in the Chukchi Sea. The study, funded by the Minerals Management Service, aims to identify important areas for bearded seal foraging, reproduction, and molting.

- A meeting with the Aleut Marine Mammal Commission (AMMC) and Tribal Government of St. Paul Island to help establish and coordinate the AMMC Sentinel Program, in which local residents of the Aleutian Islands will monitor marine mammal and other ecological occurrences and events around their communities.

- A meeting with the Alaska Native Harbor Seal Commission to discuss comanagement activities and the need to refine the definitions of harbor seal stock boundaries for better agreement with genetic and other evidence of population structure.

By Peter Boveng

Polar Ecosystems Program Prepares for Ice Seal Research Cruises

Bearded, spotted, ringed, and ribbon seals, often referred to collectively as "ice seals," are seasonally ice-associated species that may be vulnerable to climate warming through loss of sea ice. The ice seals found in the Bering Sea during spring have rarely been studied, and there are no current estimates of abundance or comprehensive descriptions of their distribution and habitat use. Further, they are critical to the nutritional and cultural sustainability of Alaska Native communities along the Bering Sea coast. Local concentrations of these animals on the ice are some of the most conspicuous indicators of prey concentrations and associated biological and physical processes in the underlying water and benthos. A fundamental understanding of these seals' abundance, distribution, and foraging ecology is therefore essential for an understanding of the mechanistic links between lower-trophic and human components of the Bering ecosystem.

From April to June 2008, the Polar Ecosystems Program (PEP) will conduct research on seals in the sea ice of the Bering Sea during three cruises: one aboard the U.S. Coast Guard icebreaker *Polar Sea*, one aboard the NOAA ship *Oscar Dyson*, and one aboard the NOAA ship *Miller Freeman*. The main objective on the *Polar Sea* will be to use the

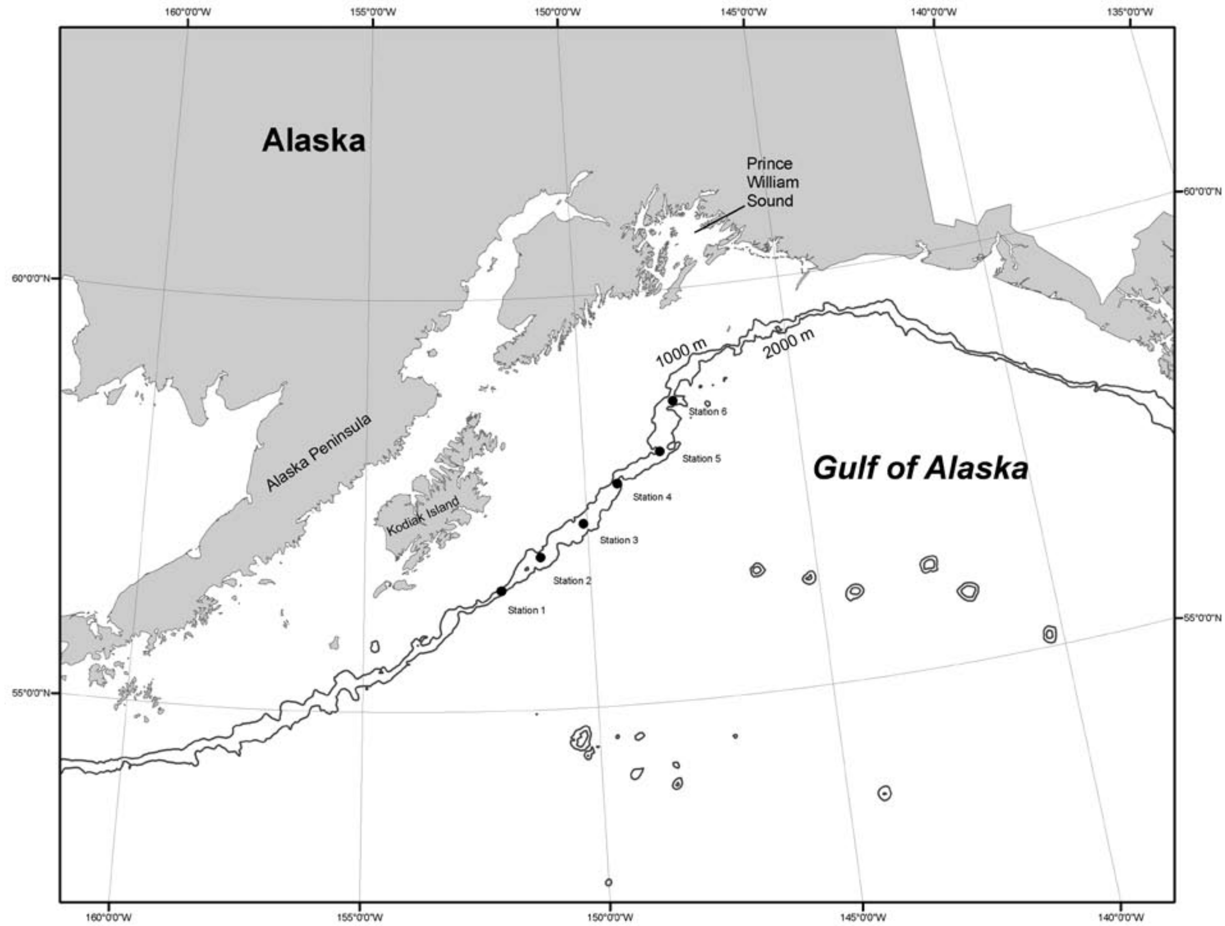

Figure 1. Map showing sites sampled along the continental shelf break in the Gulf of Alaska during the 2008 Mesopelagic Survey. Dark lines indicate the 1,000-m and 2,000-m contours.

ship's helicopter to conduct surveys of the sea ice for distribution and abundance of seals. The objectives of the *Oscar Dyson* and *Miller Freeman* cruises will be to conduct satellite-telemetry studies of movements and foraging behavior and to gain a better understanding of ribbon and spotted seals' relationships to sea ice during the critical periods of reproduction (April–*Oscar Dyson*) and molting (June–*Miller Freeman*).

In all, 16 people will participate on the PEP research teams. Three Alaska Natives with extensive local and traditional knowledge of seals and sea ice will be part of the teams, to further the goals of a comanagement agreement between NMFS and the Alaska Native Ice Seal Committee. Preparation for these cruises was a primary focus of PEP staff during January–March 2008.

More information on the cruises will be available on the PEP web page at http://www.afsc.noaa.gov/nmml/polar.

By Peter Boveng

RESOURCE ASSESSMENT & CONSERVATION ENGINEERING (RACE) DIVISION

GROUNDFISH ASSESSMENT PROGRAM

Gulf of Alaska Mesopelagic Survey

In March, the RACE Division's Groundfish Assessment Program conducted its second annual Mesopelagic Survey. The mesopelagic zone, which ranges from 200 to 1,000 m, is home to many small, deepwater fish species (e.g., lanternfish and deep-water smelts) as well as many midwater invertebrates, which form a forage base for a variety of demersal and pelagic fish species, marine mammals, and seabirds. The primary objective of this survey is to establish an index of production and species diversity in the mesopelagic zone along the shelf break in the area between Prince William Sound and southern Kodiak Island.

The 2008 Mesopelagic Survey was conducted 12–18 March aboard the NOAA ship *Miller*

Figure 2. This hatchetfish is one of the mesopelagic fishes encountered in the 2008 Mesopelagic Survey in the Gulf of Alaska.

Freeman. During the survey a total of six stations, spaced approximately 40 nautical miles (nmi) apart, were sampled along the shelf break between Kodiak and Middleton Islands in the Gulf of Alaska (Fig. 1). The gear used to sample these stations was the large, midwater Aleutian wing trawl, commonly used in RACE midwater assessments, with a ½-inch stretched-mesh liner in the codend. Each station was sampled with a daytime and a nighttime series of tows, each series consisting of three tows at 250-, 500-, and 1,000-m depths. The trawl was towed at 3 knots for 30 minutes once it had reached its target depth.

After each catch was brought aboard, all organisms were sorted to the lowest taxonomic group possible, then counted and weighed (Fig. 2). The most common species were frequently subsampled. Length frequencies, stomach samples, and individual voucher specimens were then collected. Favorable weather provided ideal survey conditions and made for a successful cruise, enabling us to complete 33 out of 36 possible tows.

By Nathan Raring

MIDWATER ASSESSMENT & CONSERVATION ENGINEERING (MACE) PROGRAM

Winter Surveys in the Gulf of Alaska

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys in the Shumagin Islands and Sanak Trough during 5-16 February aboard the NOAA ship *Miller Freeman* (Fig. 3), and in the Shelikof Strait area and along the Gulf of Alaska (GOA) shelf-break area between Chirikof and Middleton Islands during 13-31 March aboard the NOAA ship *Oscar Dyson* (Figs. 4 and 5). This was the first comprehensive EIT survey of the shelf-break area between Barnabas Trough and Middleton Island. The surveys provided data on the abundance, distribution, and biological composition of prespawning walleye pollock (*Theragra chalcogramma*). All surveys were conducted 24 hours per day.

Survey results indicated that walleye pollock abundance increased in 2008 compared to 2007 in the Shumagin Islands and Shelikof Strait areas and decreased in Sanak Trough and along the southern portion of the GOA shelfbreak in the vicinity of Chirikof Island. The densest walleye pollock aggregations were located in the southern part of the Shumagin Trough, off Renshaw Point, in the northern part of Sanak Trough, and in the southern Shelikof Strait area (Figs. 3 and 4). Few pollock were located along the shelfbreak between Barnabas Trough and Middleton Island. Dense aggregations of Pacific ocean perch (*Sebastes alutus*), however, were detected near Middleton Island and in the mouth of Amatuli Trench.

In the Shumagin Islands area, 10 cm fork length (FL) mode (age-1), and 31 cm FL mode (age-3) fish were most abundant. In the Shelikof Strait area, the size composition was broadly distributed, with modes at 12 cm FL (age-1), 24 cm FL (age-2), 31 cm FL (age-3), and most adult lengths between 50 and 65 cm FL. Walleye pollock size compositions for Sanak Trough and the shelf-break region near Chirikof GOA surveys were unimodal, with most fish between 50 and 65 cm FL. Preliminary analysis of maturity stages indicated that survey timing was appropriate for the Shumagin, Shelikof Strait, and Chirikof shelf-break but an earlier survey would be better for Sanak Trough efforts.

Miller Freeman and *Oscar Dyson* Vessel Comparison

MACE scientists continued work on vessel-comparison studies to determine whether walleye pollock differentially avoid the NOAA ships *Miller Freeman* and *Oscar Dyson*. This latest vessel-comparison work was conducted during the Shumagin Island and Sanak Trough surveys. The

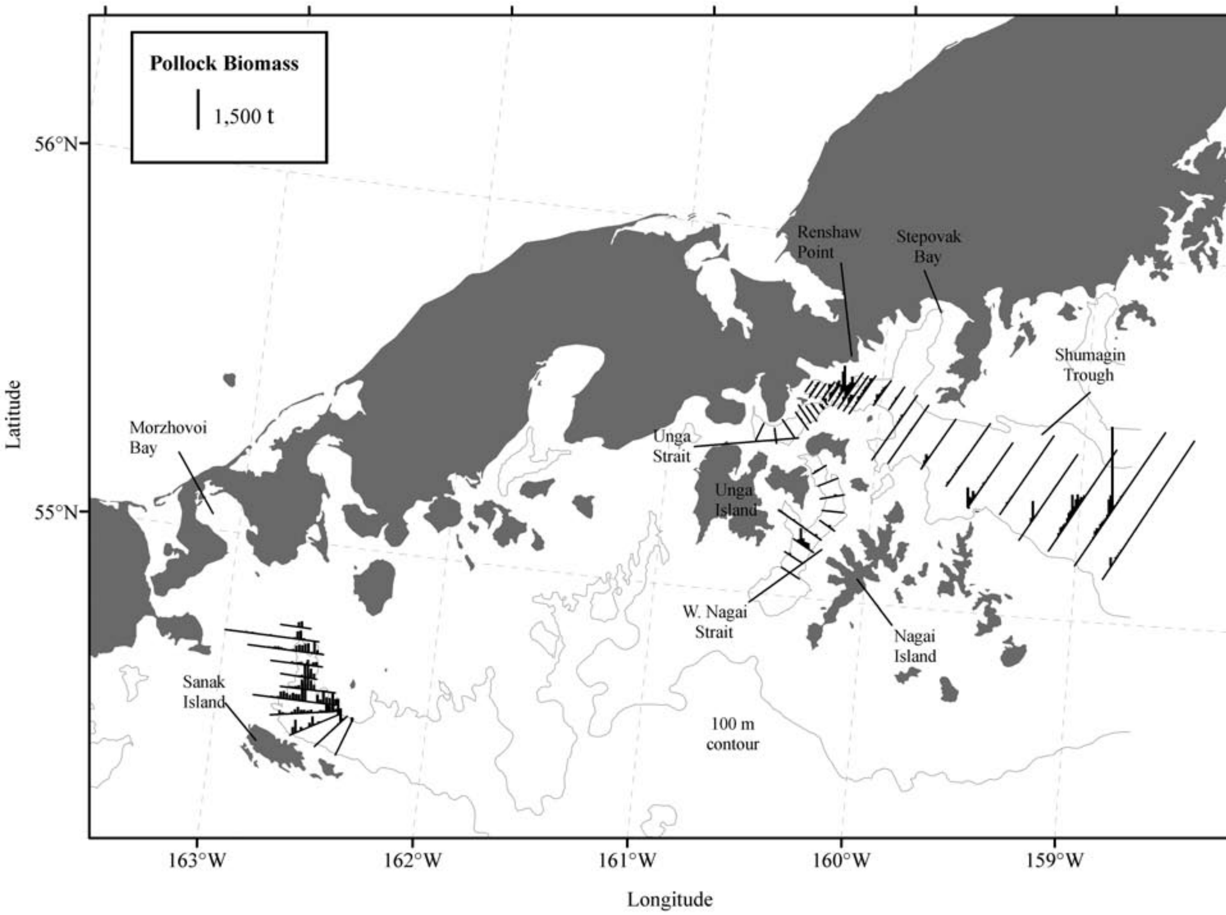

Figure 3. Estimated walleye pollock biomass in metric tons (t) (vertical lines) along transects during the February 2008 acoustic-trawl surveys of the Shumagin Islands and Sanak Trough in the Gulf of Alaska.

vessel-comparison work is needed because the *Oscar Dyson* was designed to meet the International Council for the Exploration of the Sea (ICES) specification for underwater radiated noise to minimize vessel avoidance during fish abundance surveys, whereas the *Miller Freeman* is a conventionally built vessel which exceeds this specification. Thus, fish could potentially respond differently to the vessels due to the different auditory stimuli produced by each vessel. If this were the case, differential vessel avoidance reactions could influence biomass estimates derived from standard survey methods with the two ships. This is important because the *Oscar Dyson* will be routinely used for walleye pollock acoustic-trawl surveys, which have historically been conducted with the *Miller Freeman*.

Both vessels continuously collected acoustic backscatter at 18, 38, 120 and 200 kHz while traveling in close proximity to one another. The two-part experimental design consisted of a side-by-side vessel configuration where the ships traveled beside one another at a distance of 0.5 nmi along survey tracklines, and a follow-the-leader vessel configuration where one vessel followed the other at a distance of 1 nmi. The side-by-side configuration allowed for standard survey operations without compromising the data for stock assessment purposes. Acoustic data from both vessels were collected over a wide range of densities of adult walleye pollock and conditions typical of acoustic surveys in these areas. Analyses of these data are under way. Additional vessel-comparison work with these two ships is planned during the summer 2008 eastern Bering shelf EIT survey.

Research projects addressing selectivity of the midwater trawl used during the MACE EIT surveys were conducted during the Shelikof Strait survey. Eight trawl hauls were conducted with the trawl outfitted with small recapture bags or pocket nets attached to the outside of the trawl to sample escaping fish. The pocket net catches will be compared

The Fisheries Monitoring and Analysis Division

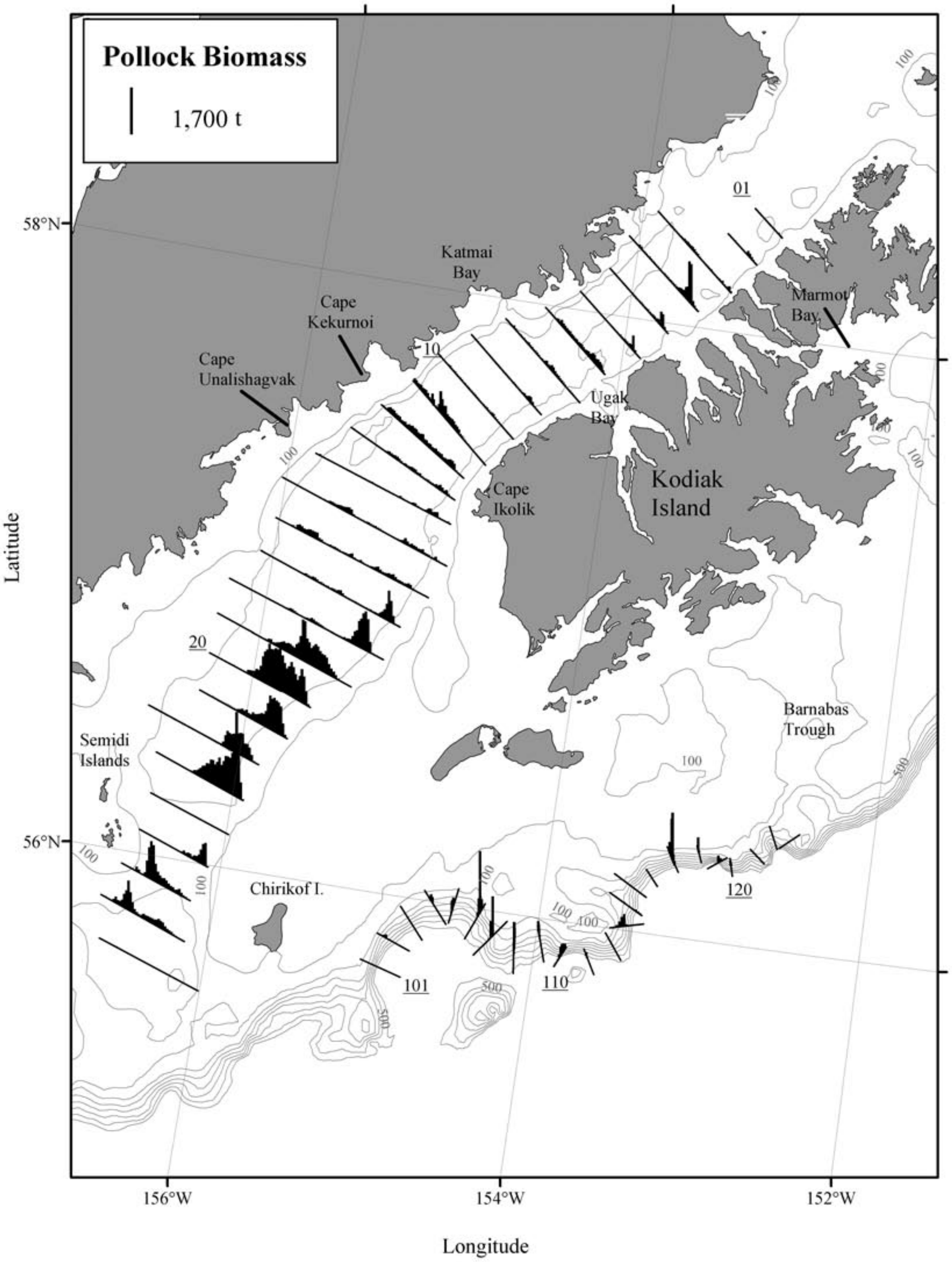

Figure 4. Estimated walleye pollock biomass in metric tons (t) (vertical lines) along transects from the March 2008 acoustic-trawl surveys of the Shelikof Strait area.

with the size and species composition of the catch retained in the codend. In addition, fish behavior in the trawl was observed using an underwater stereo-camera. The stereo-camera images are used to determine fish length. These observations will aid in the understanding of size-dependent behavior of pollock in the trawl.

By Mike Guttormsen and Chris Wilson

SHELLFISH ASSESSMENT PROGRAM: KODIAK LABORATORY

Gulf of Alaska Small-Mesh Trawl Surveys 1953-2007

Scientists at the RACE Division's Kodiak Laboratory and Alaska Department of Fish and Game (ADF&G) have been conducting small-mesh

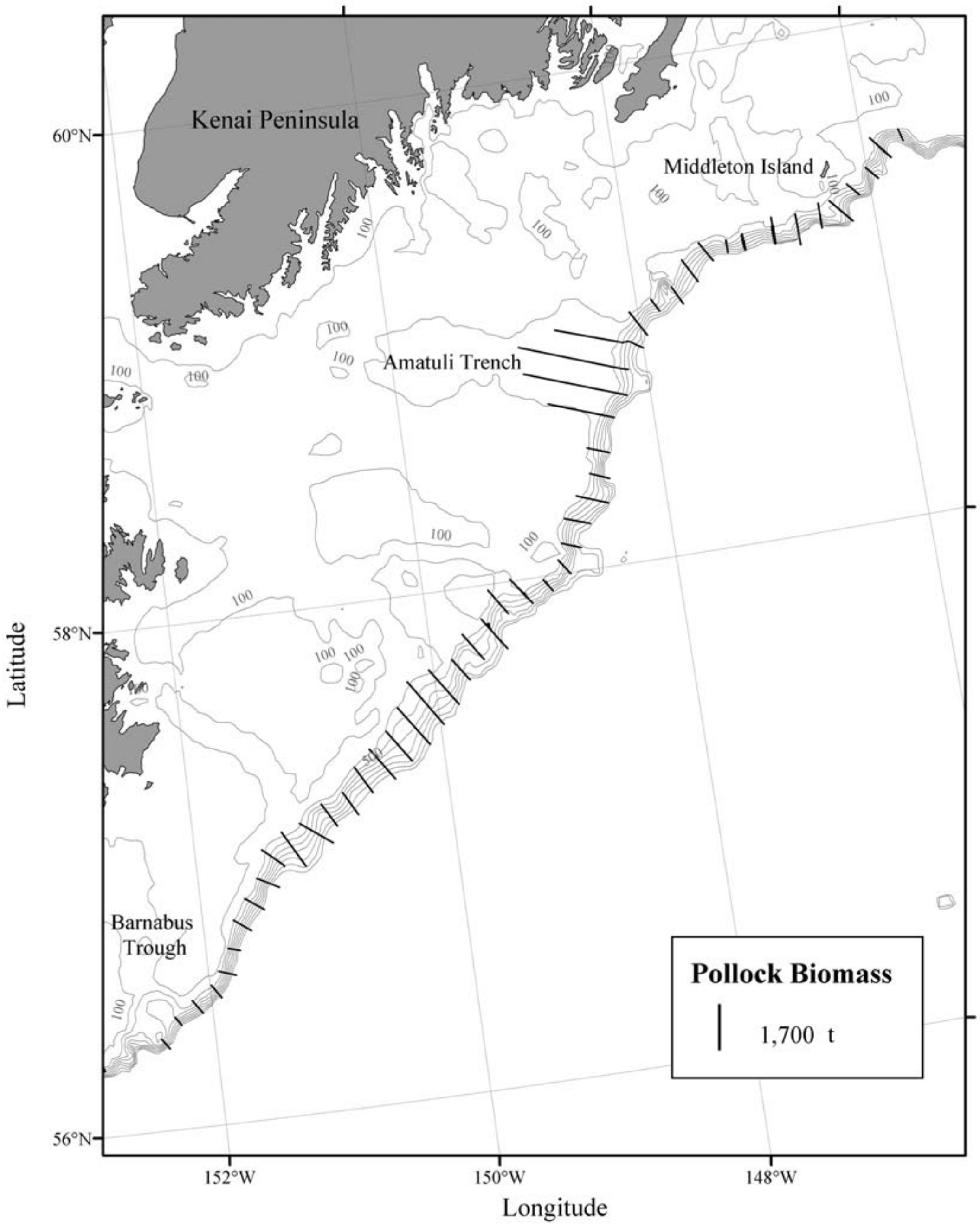

Figure 5. Estimated walleye pollock biomass in metric tons (t) (vertical lines) along the Gulf of Alaska shelf break from Barnabus Trough out to Middleton Island.

bottom trawl surveys in the Gulf of Alaska (GOA) since 1953. Surveys locations have ranged from Yakutat Bay southwest to Unalaska Island. During this period 9,973 hauls have been completed with catches with contents representing 483 different taxonomic groups. Twenty-six different vessels have participated in the survey and included in that list is the venerable NOAA ship *John N. Cobb*. The small-mesh trawl survey, originally designed to track the trends in abundance and assess the status of pandalid shrimp populations in the GOA, has become an important source of additional information on groundfish and invertebrates.

In the earliest decades of the survey, the ADF&G conducted the surveys around Kodiak Island and the north GOA coast, while the RACE Division surveyed the central shrimp grounds around the lower Alaska Peninsula, consistently in Pavlof Bay. With some variations, this was the case until 2005 when the ADF&G began conducting the entire survey, with financial and personnel assistance from the RACE Division. In the early decades of the survey, the survey gear, although designed as shrimp trawls, was inconsistent, but in 1972 the RACE Division developed a high opening, three bridle net with a 3.1-cm (stretch) mesh liner which was adopted as the standard by both ADF&G and RACE.

The small-mesh shrimp surveys in the GOA are widely recognized as the most comprehensive and longest-standing continuous time series of its type in the North Pacific. As such, it has proved a treasure trove of information of marine living resources for researchers at the Kodiak Laboratory and elsewhere. Research has focused not only on basic shrimp biology but also on the effects of climate change on the marine ecosystem. The most complete portion of the time series comes from the work in Pavlof Bay, and it was this time series that Paul Anderson (retired) and John Piatt (U.S. Geological Service) used as the basis of their seminal paper demonstrating the dramatic transition from a community dominated by northern shrimp, *Pandalus borealis,* and forage fishes to one with a preponderance of groundfish. Their paper was one of the first to demonstrate that marine community reorganization was closely associated with climate change – in this case a change seen in 1976 and 1977 that followed an interdecadal climate shift known as the Pacific Decadal Oscillation (PDO). The importance of the paper is reflected in the fact that since its publication, it has been cited in the literature at least 128 times. Abundance data from the small-mesh survey database has been further analyzed recently, further detailing the mechanisms of how climate change affects the North Pacific marine ecosystem.

At the heart of the analysis of community reorganization is the examination of trends in relative abundance of selected taxa as reflected in catch-per-unit effort (CPUE) statistics in the survey. To illustrate some key trends in the marine ecosystem from 1972 to 2007, CPUE values were calculated and are presented here for three ecologically important taxa: Pacific cod, *Gadus macrocephalus*, northern shrimp, and jellyfish of the class Scyphozoa (Fig. 6). We considered seven areas which were the most consistently sampled over the time period: Marmot Bay, Two-Headed Gully, Pavlof Bay, Kuiukta Bay, Kiliuda Bay, Alitak Bay, and Chignik-Castle Bays (Fig. 7). The relative abundance (log-transformed) for each species, expressed as kilograms of catch by

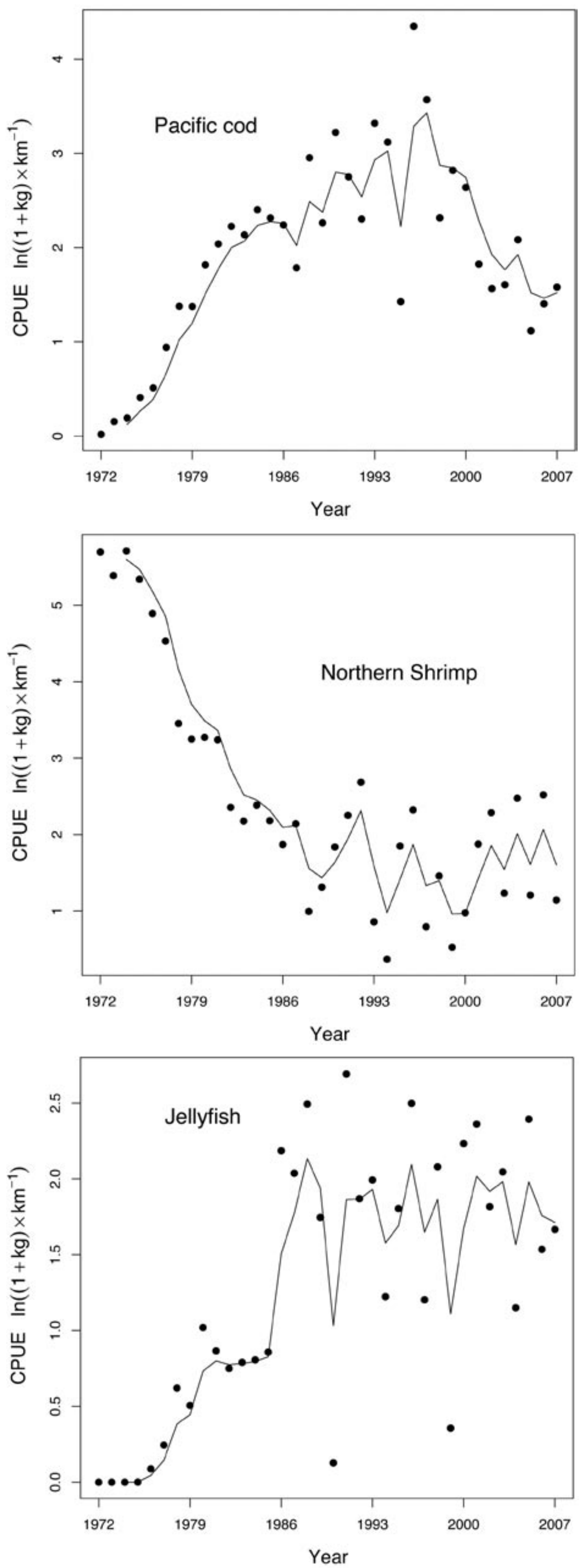

Figure 6. Trends in CPUE values observed in the Gulf of Alaska small-mesh trawl surveys for Pacific cod, northern shrimp, and jellyfish of the class Scyphozoa.

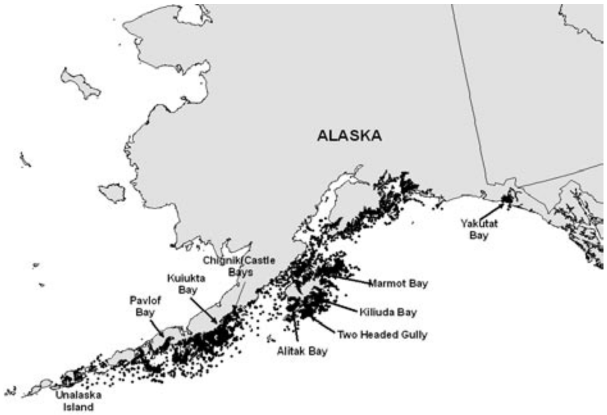

Figure 7. Map showing sites sampled in Gulf of Alaska small-mesh trawl surveys, 1953-2007.

the distance fished in kilometers (kg km^{-1}), is shown along with the running average.

Northern shrimp declined following the 1976 and 1977 climate regime shift, and the average CPUE remains an order of magnitude lower than 1970s' levels. At the same time Pacific cod CPUE rose sharply post-shift but has declined from highs of the 1980s and 1990s. Jellyfish remain at the high levels observed since the 1980s. There is evidence from the North Atlantic that cod predation on shrimp may act as a top-down control on shrimp populations, although the large commercial catches of shrimp during the 1970s and early 1980s also may have played a role in their decline (e.g., over 13,000 metric tons from Pavlof Bay in 1977). Jellyfish in the North Pacific are known to have a positive response to warmer water temperatures such as those seen post-PDO.

We anticipate the small-mesh survey time series will continue to play an important role in efforts to understand the combined effects of climate change and fishery removals on marine communities. In recognition of that importance, we are currently working in collaboration with the ADF&G on a project to update, audit, and conduct a series of quality assurance measures to ensure that the database is as accurate and complete as possible. Part of that process will include moving the complete data set to an Oracle database schema. To obtain more information about the database or for access to the database contact the Shellfish Assessment Program at the Kodiak Laboratory at (907) 481-1711.

By Brian O'Gorman and Dan Urban

FISHERIES BEHAVORIAL ECOLOGY PROGRAM: NEWPORT LABORATORY

Light, Temperature, and Food Control the Vertical Distribution of Juvenile Pacific Cod

Understanding the factors that control vertical distribution of commercially important fishes is essential for effective fisheries management. Vertical distribution of juveniles impacts survey accuracy, avoidance of bycatch, evaluation of habitat and growth conditions for recruitment, and development of accurate models for juvenile distribution and growth. Pacific cod is a species of increasing importance in north Pacific fisheries.

Groups of five similarly sized Pacific cod juveniles that were 0+, 1+, or 2+ years old and between 7 and 28 cm in length were observed during lighted conditions in an experimental sea water tank. Thermoclines were constructed in the tank and light and food conditions controlled (Fig. 8). Fish responses to low and high light, warm and cold temperature, and food were observed in a series of choice tests. Fish were tested in isothermal conditions (9°C) and in thermocline conditions (9°C in top third, 9°-3°C in the middle third, and 3°C in bottom third of tank). Food was introduced through a tube that extended into the tank.

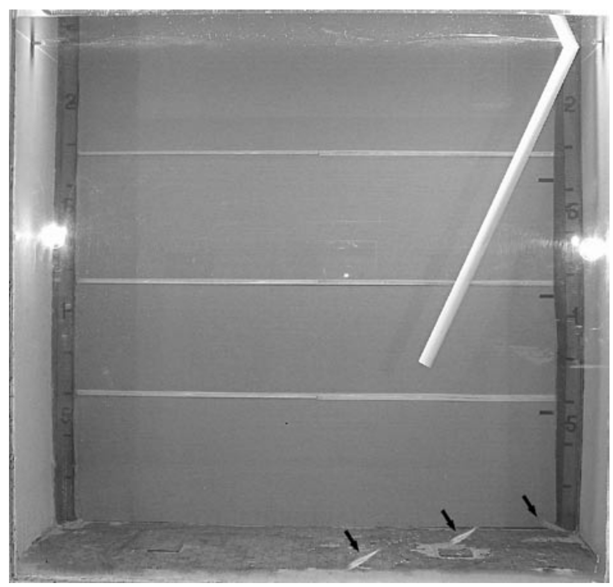

Figure 8. An experimental thermocline sea water tank (2.2 m depth, 2.2 m wide, 1.1 m across) containing five juvenile Pacific cod. Note fish swimming downward at right side of the tank. (Arrows point to fish.) White feeding tube extends to bottom third of the tank.

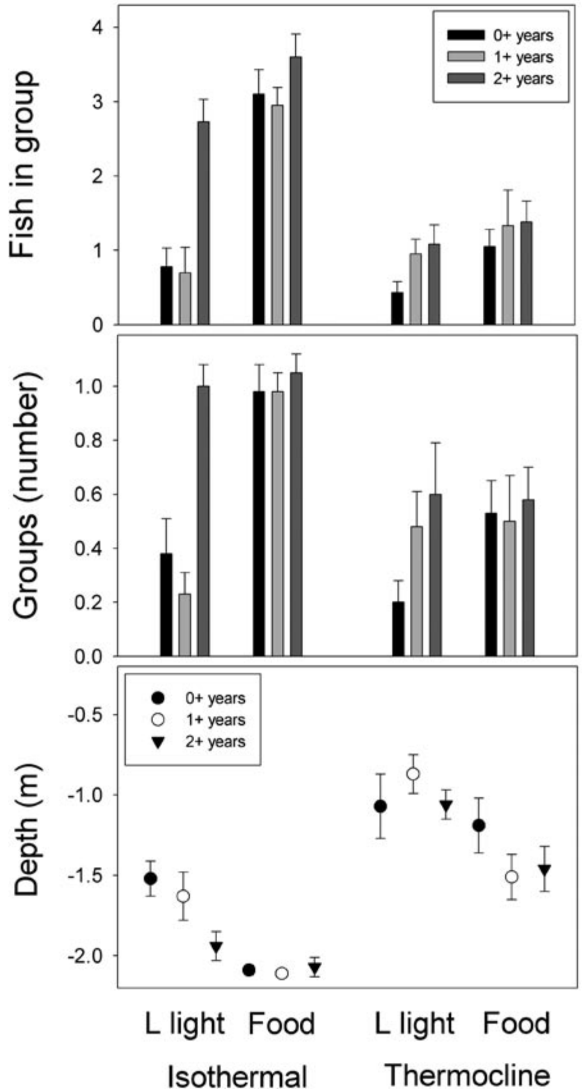

Figure 9. Responses of juvenile Pacific cod to temperature and food availability in low light conditions. Points and bars indicate mean depth, number of groups, and number of fish in groups for 0+, 1+, and 2+ year old fish (±) 1 standard error.

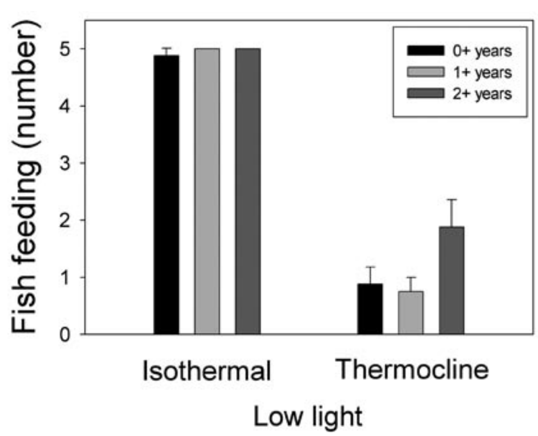

Figure 10. Bar graph showing juvenile Pacific cod feeding behavior in low light comparing isothermal and thermocline condidtions. Points and bars indicate number of 0+, 1+, and 2+ year old fish feeding (±) 1 standard error.

Pacific cod in low light avoided deeper, colder water (3°C) in a thermocline (Fig. 9). When food was introduced into the bottom third of the tank, fish swam lower in warmer water (9°C, isothermal), grouped more, and fed; while fish avoided deeper, colder water in a thermocline. Fish in low light thermocline conditions generally had a difficult time finding food and feeding (Fig. 10). Pacific cod in isothermal conditions (9°C) and low light initially moved deeper in high light (on for 1, 30, and 60 min) and then returned to shallower depths after 30 and 60 minutes in high light (Fig. 11). When a thermocline was present, fish moved deeper in response to high light, but not into colder water. Fish

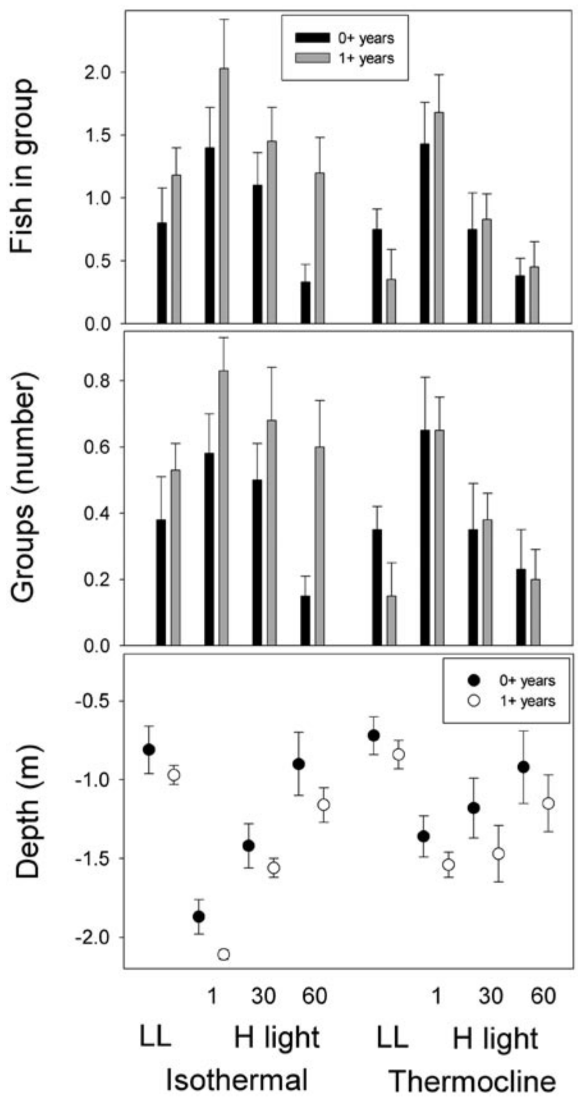

Figure 11. Responses of juvenile Pacific cod comparing low light (LL) and high light (H light) in isothermal and thermocline conditions. Points and bars indicate mean depth, number of groups, and number of fish in groups for 0+ and 1+ year old fish (±) 1 standard error.

grouped more in response to high light and then dispersed after 60 minutes.

The results of this study suggests several field-testable hypotheses: Juvenile Pacific cod remain in warmer water above thermoclines; they form groups in the presence of food or bright light stimuli; and they avoid higher light and colder temperatures, but can adapt to these conditions rapidly, suggesting that they could make excursions into areas where light and temperature are not optimal, but food is present or predators are absent.

By Michael Davis

RESOURCE ECOLOGY & FISHERIES MANAGEMENT (REFM) DIVISION

RESOURCE ECOLOGY & ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

During January through December 2008, fisheries observers returned 152 stomach samples to AFSC laboratories, and AFSC scientists collected 261 stomach samples from the eastern Bering Sea. In the Gulf of Alaska, 1,920 stomachs were collected during a mesopelagic survey and, in the Aleutian Islands region, 240 stomachs were collected on a survey conducted by the REFM Division's Fisheries Interaction Team. In the laboratory, 1,428 Bering Sea and 317 Gulf of Alaska stomach samples were analyzed . A total of 7,476 records were added to the groundfish food habits database.

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

Resource Ecology

Five common large sculpin species inhabiting the eastern Bering Sea and Aleutian Islands are being investigated for life history information. The age and growth portion of the study is concluding, with over 2,600 otoliths aged from samples collected during regional groundfish bottom trawl surveys. Results from the yellow Irish lord (*Hemilepidotus jordani*) and warty sculpin (*Myoxocephalus verrucosus*) were presented at the North Pacific Research Board (NPRB) Science Symposium held in Anchorage in January 2008 (Table 1). Age and growth analysis of bigmouth sculpin (*Hemitripterus bolini*; n = 198), plain sculpin (*Myoxocephalus jaok*; n = 788), and great sculpin samples (*Myoxocephalus polycanthocephalus*; n = 500+) is being completed. Samples collected by fisheries observers aboard vessels operating in the eastern Bering Sea will add to the total.

By Todd TenBrink

Multispecies and Ecosystem Modeling

In a recently accepted publication in the Canadian Journal of Aquatic and Fisheries Sciences, Drs. Sarah Gaichas (Resource Ecology & Ecosystem Modeling (REEM) Program) and Robert Francis (University of Washington) reviewed key concepts

Table 1. Estimates of the von Bertalanffy growth parameters for recently aged yellow Irish lord (YIL) and warty sculpin (WTY), by region (eastern Bering Sea, EBS; and Aleutian Islands, AI) and sex. Age is the maximum age estimated, r^2 is the coefficient of determination, and n is the sample size. Asymptotic standard errors are shown in parentheses below each parameter.

Species	Region	Sex	Age	L_∞	K	t_0	r^2	n
YIL	EBS	M	24	468.1 (10.86)	0.257 (0.029)	-0.070 (0.311)	0.81	140
YIL	EBS	F	28	420.6 (4.35)	0.295 (0.019)	-0.022 (0.198)	0.83	246
YIL	AI	M	20	521.7 (16.99)	0.147 (0.018)	-0.851 (0.429)	0.84	160
YIL	AI	F	26	441.6 (7.59)	0.171 (0.015)	-1.258 (0.393)	0.79	238
WTY	EBS	M	15	433.5 (11.04)	0.362 (0.059)	0.039 (0.455)	0.50	267
WTY	EBS	F	18	537.0 (7.43)	0.259 (0.022)	-0.089 (0.283)	0.76	415

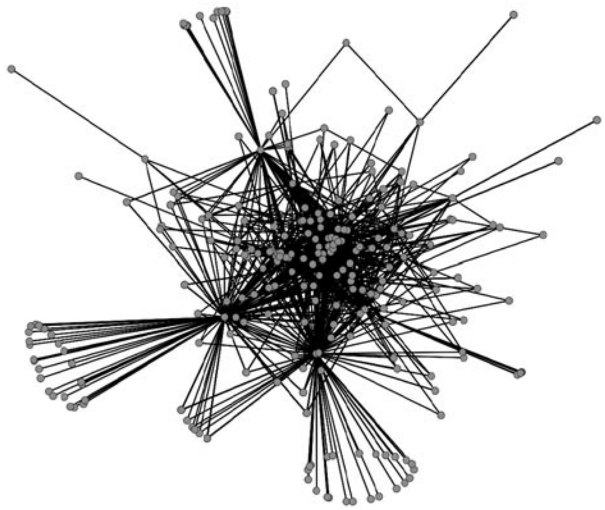

Figure 1. Network representation of the Gulf of Alaska groundfish food web in 2001.

from graph theory and network analysis that have not traditionally been used in fisheries applications. They then applied these concepts to the food web of the Gulf of Alaska marine ecosystem to classify its structural properties, which suggest how the ecosystem as a whole may respond to heavy fishing pressure on its components. Three conceptual models of network structure—random, small world, and scale free—each have different implications for system behavior and tolerance to perturbations. Gaichas and Francis constructed two food web network models using detailed quantitative information on the stomach contents of 57 predator (fish) species collected during trawl surveys of the Gulf of Alaska between 1981 and 2002. (Figure 1 shows one of the food webs, constructed using data from 2001.) The resulting food webs displayed both small-world and scale-free network properties, suggesting that impacts on one species might spread to many through short interaction chains, and that while most food web connections are not critical, a small set of fished species support critical structural connections. Gaichas and Francis concluded that ecosystem-based fishery management should, therefore, first focus on protecting the highly connected species in the network to avoid structural impacts of fishing on the food web.

By Sarah Gaichas

BSIERP Modeling Component FEAST

Dr. Kerim Aydin, REEM Program, worked on substantial development of the central modeling component of the North Pacific Research Board (NPRB) Bering Sea Integrated Research Program (BSIERP). The model, FEAST (forage and euphausiid abundance in space and time) couples fish species, particularly forage species, to nutrients and plankton production on the grid of a regional oceanographic model (ROMS).

With respect to motile predators (fish and higher trophic levels), FEAST is designed around the "landscape approach" for modeling fish foraging, mortality, and growth. The landscape approach (also known as the dynamic habitat approach) treats the space of a model as a series of layers, each layer defining a different spatial (dynamic) quantification of habitat. For example, a temperature layer, a prey density layer, a prey size layer, and a mortality layer may be used, quantifying any given point for its "growth" or "predation" potential thus determining growth and survival (dynamic state variables) of the fish. The landscape approach has been successful, for example, at predicting the distance at which fish congregate around a front; in a front between warm and cold water, warm or cold adapted fish will approach the front from either side, stopping where gain from frontal concentrations of prey are cancelled out by thermal stress. This can be a powerful tool for modeling dynamic climate scenarios in which fronts shift, break down, or otherwise change over time.

By Kerim Aydin

Seabird Research: 35th Annual Meeting of the Pacific Seabird Group

Shannon Fitzgerald attended the 35th Annual Meeting of the Pacific Seabird Group (PSG) from 27 February to 1 March in Blaine, Washington. He participated in the PSG Seabird Monitoring Committee and North Pacific Albatross Working Group meetings prior to the start of the full conference. At the albatross working group, albatross bycatch for Alaskan and Hawaiian fisheries were reported (with acknowledgements to Lewis VanFossen of the Pacific Islands Regional Office for providing summaries of the Hawaiian bycatch prior to this meeting). While at the conference, Fitzgerald made the presentation, "The Trouble With Trawlers and Seabirds in the North Pacific Groundfish Fishery (ies)," which highlighted what is currently known of seabird bycatch in the trawl fleet, identified several sources of mortality that are not observed, and identified other approaches that help to inform us about seabird/trawl fishery interactions. Fitzgerald also presented the poster, "Research–Regulation–Operation: An Evaluation of the Effectiveness of Seabird Mitigation Requirements in the Alaskan Demersal Groundfish Longline Fleet" (Shannon Fitzgerald, Renold Narita, and Kim Rivera). The poster noted that seabird bycatch has decreased from an annual average (1993-2000) of 16,507 down to an annual average (2002-06) of 5,137 (Fig. 2). Research done by Washington Sea Grant in 1999-2000 indicated that streamer lines were especially effective for reducing albatross bycatch. The average annual albatross bycatch for 1993 through 2000 was 1,051, while the annual average for 2002-06 was 185. The research was originally designed to evaluate mitigation gear under commercial operations and to recommend actions that would be effective and relatively easy to use by fishers. Based on the general evaluation provided in this poster it appears that those research objectives were met.

Stephani Zador also attended the Pacific Seabird Group meeting. Dr. Zador, a member of the local organizing committee, attended the North Pacific albatross working group meeting and gave a presentation titled "Determining Spatial and Temporal Overlap of an Endangered Seabird With a Large Commercial Trawl Fishery" in a session on seabird and fisheries interactions. The presentation reviewed a risk assessment conducted by Dr. Zador and others that compares multiple methods to quantify overlap between short-tailed albatross and the Alaskan groundfish trawl fishery.

By Shannon Fitzgerald and Stephani Zador

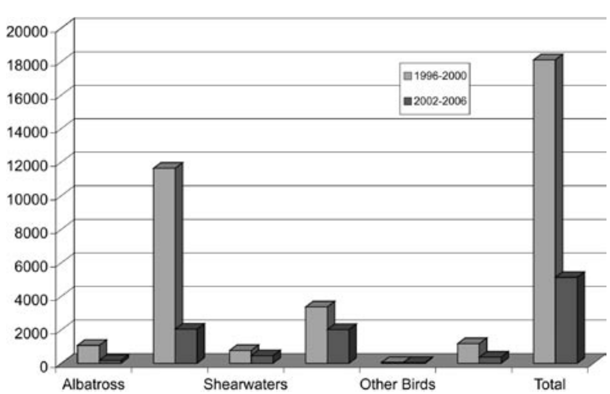

Figure 2. Annual average seabird bycatch during 5-year periods before and after streamer line use in the demersal groundfish longline fishery.

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Public Attitudes Toward Threatened and Endangered Species and Steller Sea Lions

As reported in the October-November-December 2007 issue of the AFSC *Quarterly Report*, a public survey conducted by Dr. Dan Lew (Economics and Social Science Research (ESSR) Program), David Layton (University of Washington), and Stratus Consulting to understand the public's preferences for providing additional protection to the threatened and endangered stocks of Steller sea lions was completed in late 2007. The survey collected information necessary to estimate the public's preferences and values for providing additional protection to Steller sea lions. The survey also collected other information from randomly-selected Alaska households and other U.S. households (U.S. households outside Alaska) useful for understanding public preferences for, and attitudes about, threatened and endangered species generally and Steller sea lions particularly. These preferences and attitudes are summarized below. Econometric model results from the analysis of the stated preference choice questions also collected in the survey will not be presented below since this is an area of ongoing work.

In general, Alaskan and other U.S. respondents had very similar views on the Endangered Species Act, with over 70% of respondents in each sample having a positive view of the law (Fig. 3). Respondents were asked the extent to which they agreed or disagreed with two statements about threatened and endangered species, "Protecting threatened and endangered species is important to me" (Fig. 4) and "Protecting jobs is more important than protecting threatened and endangered species" (Fig. 5). In each question, Alaskan and other U.S. respondents had similar distributions of responses.

The survey provides basic information about Steller sea lions and describes the two stocks of Steller sea lions in the United States, the *threatened* Eastern Stock and *endangered* Western Stock, and the population trends of each. The Eastern Stock has been increasing for a number of years. Until recently, the Western Stock as a whole has been decreasing. Alaskans tended to be more knowledgeable and experienced with Steller sea lions, with about 92% of Alaskan respondents indicating they had seen, heard, or read about them compared with about 40% of other U.S. respondents. Over 40% of respondents in each sample (44% of Alaska respondents and 41% of other U.S. respondents) indicated they are "very concerned" or "extremely concerned" about the Western Stock. In contrast, the proportion of respondents in each sample that is "very concerned" or "extremely concerned" about the Eastern Stock is lower (23% of Alaska respondents and 25% of other U.S. respondents).

The survey also presents information and asks the respondents how concerned they are about possible costs of additional protection, including the possibility of commercial fishing jobs being lost and higher prices for seafood that may result as the fishing industry adjusts to commercial fishing restrictions that may occur as part of measures to protect Steller sea lions. Most respondents in each sample either indicated they were "a little concerned" or "somewhat concerned" (63% of Alaska respondents and 70% of other U.S. respondents). A higher proportion of Alaskans were "very concerned" or "extremely concerned" (22%) compared to non-Alaskans (16%). Regarding concern about the possibility of higher seafood prices, the most frequently selected response in each sample was "not at all concerned" (36% of Alaskan respondents and 33% of other U.S. respondents). About 17% of Alaskan respondents and 15% of other U.S. respondents were "very concerned" or "extremely concerned" about higher seafood prices that may result from more Steller sea lion protection.

To qualitatively gauge respondents' preferences for the need for further protection actions, respondents were asked the extent to which they agreed or disagreed with two statements: "Even if it costs us more money, we should do more so the Western Stock is no longer endangered" and "So long as the Eastern Stock recovers, it doesn't matter to me if the Western Stock remains endangered." Over 60% of respondents in each sample indicated they "strongly agree" or "somewhat agree" with the first statement (62% of Alaska respondents and 61% of other U.S. respondents), indicating the majority of each sample believe more should be spent to ensure the Western stock is no longer endangered. A similarly large proportion of respondents in each sample indicated they "strongly disagree" or "somewhat disagree" with the second statement (74% of Alaska respondents and 67% of other U.S. respondents), suggesting the majority of respondents feel protecting the Western Stock is independent of how the Eastern Stock is doing.

By Dan Lew

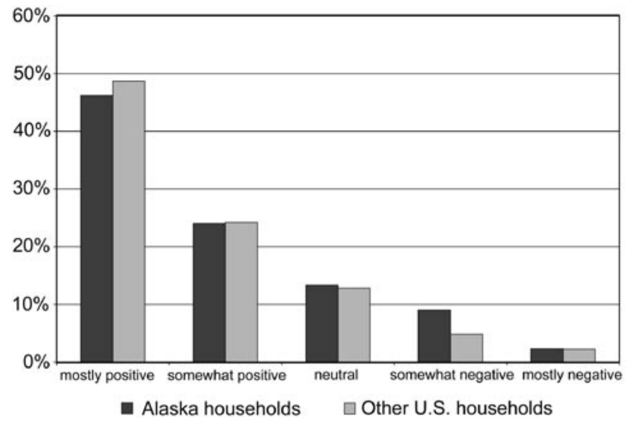

Figure 3. When you think of the Endangered Species Act, how positive or negative is your general reaction?

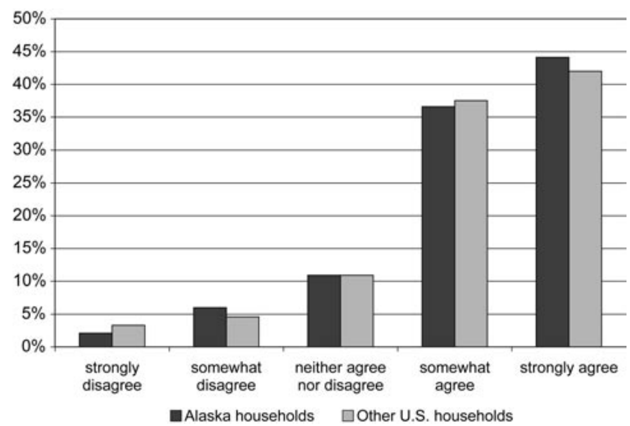

Figure 4. How much do you agree or disagree with the statement, "Protecting threatened and endangered species is important to me"?

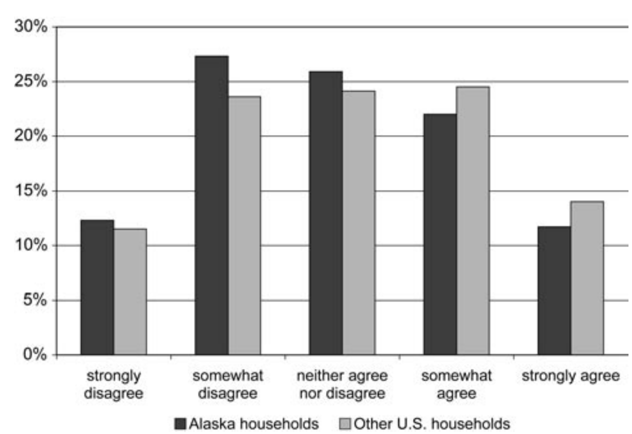

Figure 5. How much do you agree or disagree with the statement, "Protecting jobs is more important than protecting threatened and endangered species"?

Developing a Dynamic Multiregional Economic Model for Alaska Fisheries

Standard regional economic models usually focus on a single region. These models generally fail to capture economic impacts transmitted outside that region and also do not account for spillover effects in the study area resulting from events occurring outside. In addition, products from Alaska fisheries are consumed around the world, and global demand for these products is an important source of income to Alaskan fishers, processors, and traders.

An inter-regional (or multiregional) model can more fully measure the impacts of a region's fisheries, including impacts occurring in regions that supply commodities or factors of production to industries in the study region, or that purchase goods and services produced there. An inter-regional model could be especially useful in the case of Alaska, where most intermediate goods and services are imported, and much of the factor (labor and capital) income is paid to nonresident vessel owners and crew members. This type of model could also be used to track the impact of expenditures by vessel owners and crew members who participate in other regions' fisheries. Similarly, U.S. regional economic accounts distinguish between domestic versus foreign trade, but do not identify bilateral trade flows between partners. However, information about the volume and value of trade between partners is important for understanding the current and historic economic status of a fishery, and, thus, for making reasonable projections about future economic conditions in scenarios that account for important current issues such as the effects of climate change or ocean acidification.

Existing economic impact models for fisheries usually focus on impacts from regulations imposing supply-side shocks (e.g., change in harvest levels) or change in exogenous demand for seafood products. With these models it is difficult to disentangle and evaluate the effects of changes in market conditions (e.g., changes in the world market price of seafood) and changes in global demography (e.g., population and age structure in consuming countries). Demand for seafood products is expected to increase substantially in coming decades due to these demand-side effects. On the supply side, emerging issues of importance to fisheries and seafood production systems include climate change and ocean acidification. These issues are expected to receive greater attention as more is learned about their effects on the productivity of ocean ecosystems.

Therefore, ESSR Program economists Drs. Chang Seung and Mike Dalton and contractors Phil Watson and Edward Waters will construct a dynamic multiregional computable general equilibrium (DMRCGE) model to incorporate and integrate the important drivers of seafood product supply and demand. The DMRCGE model will enable examination of the inter-regional effects of not only regulatory-induced supply-side perturbations but also of changes in world seafood market conditions, changes in world demography, global climate change, and ocean acidification. Intermediate steps include the construction of a multiregional social accounting matrix (SAM) model, and construction of a "static" multiregional computable general equilibrium (CGE) model.

By Chang Seung

A Tradable Salmon Bycatch Quota System for the Pollock Fishery?

The Bering Sea pollock fishery has experienced a significant increase in benefits from economic rationalization brought about by the American Fisheries Act which was passed in 1998. The "race for fish" ended in the fishery, product recovery increased markedly, and intercooperative agreements (ICA) have allowed the participants in the fishery to jointly address problems through civil contracts. Two notable benefits of the ICA are increased information sharing on bycatch and the development of voluntary rolling hotspots (VRHS) which close areas of the Bering Sea for periods of time after observations of spatially aggregated high-bycatch areas.

Despite aggressive action by industry to close Chinook and 'other salmon' bycatch hotspots, the fishery experienced record levels of Chinook bycatch in 2007. The North Pacific Fishery Management Council (NPFMC) is currently evaluating a large suite of potential policies including both new spatial closures and the imposition of a limit or "hard-cap" on the amount of salmon that can be caught in the pollock fishery before the fishery is closed.

Creating a hard cap will by definition limit the quantity of salmon caught in the pollock fishery, but without allowing for individual or cooperative-level allocations of salmon, a hard cap could restart the race for fish in the pollock fishery. This would occur if participants in the pollock fishery expect the fishery to close early due to the fleet reaching the salmon hard-cap, causing cooperatives to speed up fishing to ensure that their pollock quota can be fished before it is lost.

Fortunately, tradable salmon bycatch quotas or other individual bycatch accountability (IBA) mechanisms can help to efficiently ensure that the benefits of rationalization continue to be experienced by the pollock fishery. A tradable salmon quota system would require that vessels hold salmon quota in order to fish for pollock. Tradable quotas would not cause a race for fish because vessels or cooperatives would be able to fish their entire pollock quota as long as they possess or can purchase bycatch quota.

Under the current system or under a hard-cap system without tradable bycatch quota, bycatch is a classic environmental externality—the vessel choosing whether or not to fish in a high or low bycatch area pays the cost of traveling to avoid bycatch. However, the vessel does not pay the cost of generating additional salmon bycatch; this is experienced by the fleet as a whole (and other users of salmon). A tradable bycatch quota system would require vessels to pay a direct cost for salmon bycatch and would, thus, provide efficient incentives for vessels to decide whether or not to take action to avoid bycatch or to instead expend bycatch quota to avoid the costs of traveling to cleaner areas. A quota system is a market-based regulation rather than a "command and control" system. Rather than putting the decision about what area to control in the hands of a regulator, the decision to avoid bycatch is put in the hands of every individual making the tradeoff of fishing benefits and (all) bycatch costs. This means that vessels can choose whatever means of bycatch reduction that they see fit, be it avoiding hotspots, fishing more intensively in different times of the year, or using salmon excluders or other alternative fishing technologies that might reduce bycatch.

As part of the suite of alternatives being considered, the NPFMC is considering a tradable salmon bycatch system; it is also possible that the pollock industry ICA would allow industry to organize a tradable salmon system that they could administer. Various challenges remain in the implementation process, however; while the pollock fleet has a relatively high level of observer coverage, approximately 20% of catch remains unobserved. There are also legal challenges to trading prohibited species catch (PSC) such as salmon. During the coming months NPFMC staff and AFSC researchers will continue to consider options for a tradable salmon bycatch system.

By Alan Haynie

Community Profiles Published for Washington, Oregon, and Other U.S. States Showing Involvement in West Coast and North Pacific Fisheries

A NOAA Technical Memorandum profiling communities involved in West Coast and North Pacific Fisheries was published recently by the Northwest Fisheries Science Center (NWFSC) (NOAA Technical Memorandum NMFS-NWFSC-85). The result of a joint project between the NWFSC, AFSC, and Southwest Fisheries Science Center (SWFSC), the document profiles 125 fishing communities in Washington, Oregon, California, and two other U.S. states with basic social and economic characteristics and a compilation of information regarding participation in fisheries along the West Coast and in the North Pacific. The publication is a companion volume to the Alaska profiles, which used the same basic format to profile communities in Alaska and their participation in North Pacific fisheries.

The profiles are provided in a narrative format with four sections: 1) People and Place, 2) Infrastructure, 3) Involvement in West Coast Fisheries, and 4) Involvement in North Pacific Fisheries. "People and Place" includes information on location, demographics (including age and gender structure of the population, racial, and ethnic make up), education, housing, and local history. "Infrastructure" covers current economic activity, governance (including city classification, taxation, and proximity to fisheries management and immigration offices), and facilities (transportation options and connectivity, water and waste water, solid waste, electricity, schools, police, public accommodations, and ports). "Involvement in West Coast Fisheries" and "Involvement in North Pacific Fisheries" detail community activities in commercial (processing, permit holdings, and aid receipts), recreational, and subsistence fishing.

The community selection process assessed involvement in commercial fisheries using quantitative data from the year 2000, in order to coordinate with 2000 U.S. Census data. Census place-level geographies were used where possible to define communities, yielding 125 individual profiles. Quantitative indicators measured fisheries involvement in communities with commercial fisheries landings (weight and value of landings, number of unique vessels delivering fish to a community) and communities home to documented participants in the fisheries (state and federal permit holders and vessel owners). These indicators were assessed in two ways, as a ratio to the community's population and as a ratio of involvement within a particular fishery. A data envelopment analysis model enabled a multivariate analysis to rank communities in terms of participation in commercial fisheries. The ranked lists generated by these two processes were combined and communities with scores one standard deviation above the mean were selected for profiling. The model is described in more detail in the AFSC *Quarterly Report* for July-August-September 2007 (http://www.afsc.noaa.gov/Quarterly/jas2007/divrptsREFM5.htm#model)

The communities profiled are as follows.

WASHINGTON

Aberdeen, Anacortes, Bay Center, Bellingham, Blaine, Bothell, Cathlamet, Chinook, Edmonds, Everett, Ferndale, Fox Island, Friday Harbor, Gig Harbor, Grayland, Ilwaco, La Conner, La Push, Lakewood, Long Beach, Lopez Island, Mount Vernon, Naselle, Neah Bay, Olympia, Port Angeles, Port Townsend, Raymond, Seattle, Seaview, Sedro-Woolley, Sequim, Shelton, Silvana, South Bend, Stanwood, Tacoma, Tokeland, Westport, and Woodinville.

OREGON

Astoria, Bandon, Beaver, Brookings, Charleston, Clatskanie, Cloverdale, Coos Bay, Depoe Bay, Florence, Garibaldi, Gold Beach, Hammond, Harbor, Logsdon, Monument, Newport, North Bend, Pacific City, Port Orford, Reedsport, Rockaway Beach, Roseburg, Seaside, Siletz, Sisters, South Beach, Tillamook, Toledo, Warrenton, and Winchester Bay.

CALIFORNIA

Albion, Arroyo Grande, Atascadero, Avila Beach, Bodega Bay, Corte Madera, Costa Mesa, Crescent City, Culver City, Dana Point, Dillon Beach, El Granada, El Sobrante, Eureka, Fields Landing, Fort Bragg, Half Moon Bay, Kneeland, Lafayette, Long Beach, Los Angeles, Los Osos, Marina, McKinleyville, Monterey, Morro Bay, Moss Landing, Novato, Oxnard, Pebble Beach, Point Arena, Port Hueneme, Princeton, San Diego, San Francisco, San Jose, San Pedro, Santa Ana, Santa Barbara, Santa Cruz, Santa Rosa, Sausalito, Seaside, Sebastopol, Sunset Beach, Tarzana, Terminal Island, Torrance, Trinidad, Ukiah, Valley Ford, and Ventura.

OTHER U.S. STATES

Pleasantville, New Jersey, and Seaford, Virginia (both of which have concentrations of ownership engagement in North Pacific scallop fisheries).

Community Profiles for West Coast and North Pacific Fisheries—Washington, Oregon and Other U.S. States can be downloaded at http://www.nwfsc.noaa.gov/publications/displayinclude.cfm?incfile=technicalmemorandum2007.inc (see NMFS-NWFSC-85). Community Profiles for North Pacific Fisheries—Alaska can be downloaded at http://www.afsc.noaa.gov/Publications/techmemos.htm (see NMFS-AFSC-160).

By Jennifer Sepez and Karma Norman

An Analysis of Place, History, and Globalization in Unalaska/Dutch Harbor

Dr. Jennifer Sepez and colleagues published an article in the journal *Polar Geography* entitled "Unalaska, Alaska: memory and denial in the globalization of the Aleutian landscape." The article explores the history and globalization of the landscape of Unalaska/Dutch Harbor. The article grew from fieldwork conducted in Unalaska in 2002 by Dr. Sepez and her presentation at a session on reading history in the landscape at the American Anthropological Association meetings. The article included contributions, also based on fieldwork in the Aleutians, from coauthors Christina Package (Oregon State University—formerly with the AFSC), Patrica Malcolm (Western Washington University), and Amanda Poole (University of Washington—formerly with the AFSC).

The Aleutian landscape is shaped by its history of foreign and domestic exploitation, wartime occupation and displacement, economic globalization, and the historical narratives and identities that structure the relationship of past and present through place. In the article, the history of the area is characterized by successive waves of occupation and resource extraction by the geopolitical powers of Asia and North America, which began with Russian colonization. Of particular focus is the legacy of World War II, characterized as an array of both presences and absences. Obvious to most all who visit the Aleutians is the presence of World War II debris from Japanese attacks in 1942. Less obvious are the absences of Aleut villages and the community social structures that bound them together. The article compiles information on the 10 Aleut villages that were forcibly evacuated by the U.S. Government, resulting in years of brutal internment of the entire indigenous Aleut population. Only six of these villages (four in the Aleutians and two in the Pribilofs) were permitted resettlement after the war. Since that time, the Port of Dutch Harbor has grown to become the Nation's busiest commercial fishing port, ironically due to the demand of the Japanese market for fishery products and substantial capital investment by Japanese companies. The article includes a description of the current fishing industry based in Dutch Harbor, including its global markets and labor force. Applying post-colonial theory to Unalaska's history suggests that historical power asserted by conquest and territorial acquisition has been succeeded by the dynamics of economic globalization in this American periphery. Residents draw on the legacy of history and globalization to shape and contest identity and power in the modern landscape.

By Jennifer Sepez

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

Stock Assessment Improvement Workshop

Stock assessment scientists from the Status of Stocks and Multispecies Assessment (SSMA) Program in Seattle and the Marine Ecology and Stock Assessment (MESA) Program at Auke Bay Laboratories in Juneau, Alaska, held an internal stock assessment improvement workshop on 5 March. Despite being physically separated by almost a thousand miles, the two groups of scientists utilized state-of-the-art video conferencing technology and internet collaboration software to provide real-time linkage between the two programs. The joint workshop was held to facilitate communication among stock assessment scientists within the AFSC on a variety of topics ranging from "tips and techniques" to the requirements of the recently reauthorized Magnuson-Stevens Fishery Conservation and Management Act. Other discussion topics included revisions to guidelines for Stock Assessment and Fishery Evaluation (SAFE) documents, approaches for incorporating and reflecting uncertainty in harvest control rules, methods to incorporate length-based or time-varying selectivity in assessment models, and management strategy evaluations. Invited speakers from other AFSC programs also briefed the scientists on ecosystem analyses (REEM Program), upcoming changes to the Observer Program's fisheries database (FMA Division), and the status of several scientific surveys that provide critical information for assessments (RACE Division).

By William Stockhausen

Eastern Bering Sea Pollock Fishery

Research on aspects of the biology of walleye pollock and management implications continues to be actively pursued within the REFM Division. The issues facing fisheries management in Alaska are growing in complexity and pose new challenges. These issues include implementing practical regulations that satisfy a diverse set of biological, economic, and ecosystem objectives. The largest fishery, walleye pollock in the eastern Bering Sea, enjoys a number of unique characteristics. Under the current regime, for example, two scientific observers are deployed on each vessel and extensive real-time reporting is required. The fact that this fishery is regulated to use only pelagic trawls (though bottom contact does occur) results in reduced bottom-habitat disturbance and reduced bycatch of nontarget species. Also, the fishery operates within strict catch limits by seasons and areas. The highest value from this fishery is derived from the production of prespawning roe. The rationalization of the fishery (whereby entry is limited and participating fishers are granted rights to a proportion of the annual quota) has further enhanced the value of the fishery since waste has declined.

From a biological perspective, the high level of observer coverage, combined with regular extensive surveys provides a unique situation to directly apply fisheries population dynamics theory into management. This provides the first tier of resource protection—that which avoids overfishing on a

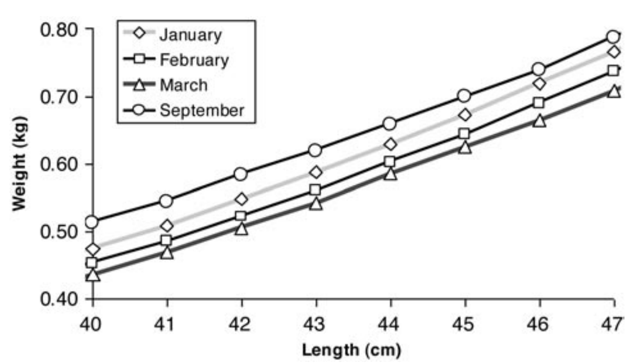

Figure 6. Mean pollock body mass (kg) given length (cm) for the eastern Bering Sea stock by month based on NMFS fishery observer data, 1991-2006.

single-species basis. As an example of the applicability and extent of observer data, fine-scale patterns in growth (expressed as body weight for given lengths) reveal distinct monthly declines through the winter months followed by "fattest" conditions in September (Fig. 6). This type of information, also broken out by regions, provides signals that reflect changes in environmental conditions that affect how management recommendations are formulated.

The next tier of conservation considers the multispecies aspect of the fishery whereby any bycatch is recorded and counted against separate quota levels. Additionally, the annual overall multispecies limit of 2.0 million metric tons (t) for groundfish catch in this region impacts the levels of fishing mortalities for individual stocks. Recent developments on management strategy evaluations for eastern Bering Sea pollock and yellowfin sole were presented at the February North Pacific Fishery Management Council meeting in Seattle. Results from this work show how management decisions for these stocks, given the overall constraint, are likely to play out under various productivity hypotheses (e.g., Fig. 7). During periods of high pollock abundance levels, depending on the multispecies aspect of fisheries performance, the full 2.0 million t is nearly taken. During other years, in fisheries with higher levels of nontarget bycatch (e.g., flatfish fisheries), it is more difficult for the fleets to catch the 2.0 million t optimum yield (OY).

The levels of salmon bycatch in the eastern Bering Sea pollock fishery have increased in recent years, despite proactive management measures designed to reduce bycatch. Consequently, alternative management measures are being proposed and an environmental impact statement is currently under way. The pollock stock in this region has dropped below the expected long-term average in 2008, and there was concern that increases in fishing effort may exacerbate bycatch. However, data on effort by the fleet show only a slight increase, whereas the Chinook salmon bycatch was nearly three times above average (Fig. 8). The preliminary levels recorded for the first quarter of 2008 in this fishery appear to be back below mean levels. However, the new management measures (anticipated to be in place by late 2009) will add further restrictions on the pollock fishery, particularly in years where Chinook salmon abundance is high.

By James Ianelli

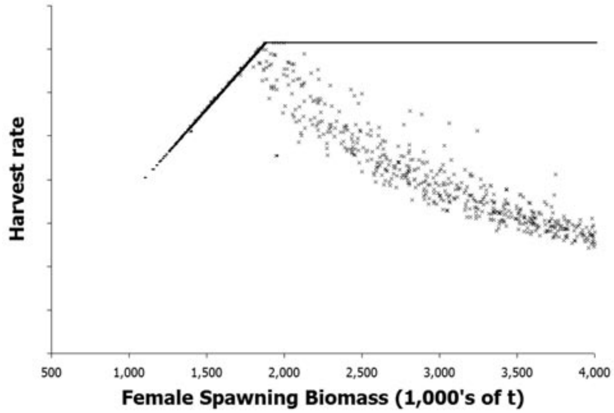

Figure 7. Scatter-plot results of simulation modeling of the present management strategy for eastern Bering Sea pollock showing how harvest rates change and when an upper limit of 1.5 million t TAC (pollock only) is imposed.

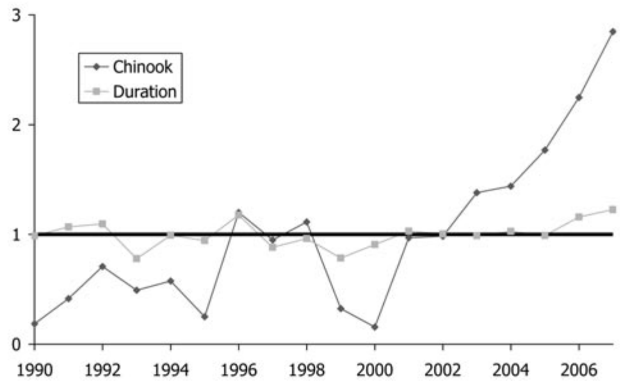

Figure 8. Normalized (to have mean value equal to one) estimates of pollock trawl effort (duration) and Chinook salmon bycatch, 1990-2007.

FIT and SSMA Personnel Lead Winter Survey in the Central Aleutian Islands

Scientists from the SSMA Program's Fishery Interaction Team (FIT) conducted one of the first wintertime surveys of walleye pollock in the central Aleutian Islands in February 2008. The cruise was conducted from 16 February to 3 March on board the NOAA ship *Oscar Dyson*. The primary objective of the cruise was to collect acoustic and trawl data necessary to determine the distribution, biomass, and biological composition of walleye pollock in the central Aleutian Islands region between Seguam Pass and Tanaga Island. The cruise was part of a larger effort funded by the North Pacific Research Board to assess the spatial and temporal patterns in pollock distribution near Steller sea lion rookeries and haulouts.

The cruise was also an ecosystem survey, so several other objectives were included in the cruise plan. Physical oceanographic data (temperature, salinity, chlorophyll, and nutrient profiles) were collected at selected sites with conductivity-temperature-depth (CTD) profilers and Niskin bottle water samples. Sea surface temperature, salinity, nitrate, and fluorescence data were collected continuously throughout the cruise. Bongo nets were deployed at selected sites to sample ichthyoplankton and zooplankton. Stomach specimens and gonads from selected species were collected to elucidate key predator-prey relationships and spawning behavior in the Aleutian Islands region. Seabird and marine mammal surveys were conducted by scientists from the U.S. Fish and Wildlife Service (USFWS) and the AFSC's National Marine Mammal Laboratory, respectively. There were also several special projects completed, such as the collection of gadoid fish livers, genetic samples, and samples for microchemical analysis of fish eye lenses and otoliths. Additional details of this survey are provided below.

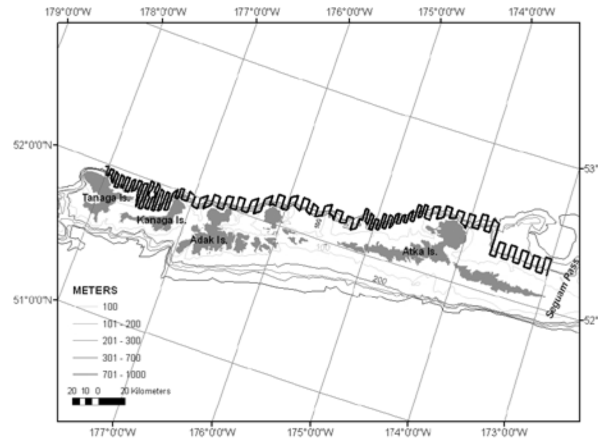

Figure 9. Acoustic survey transects of the February 2008 *Oscar Dyson* survey of walleye pollock in the central Aleutian Islands.

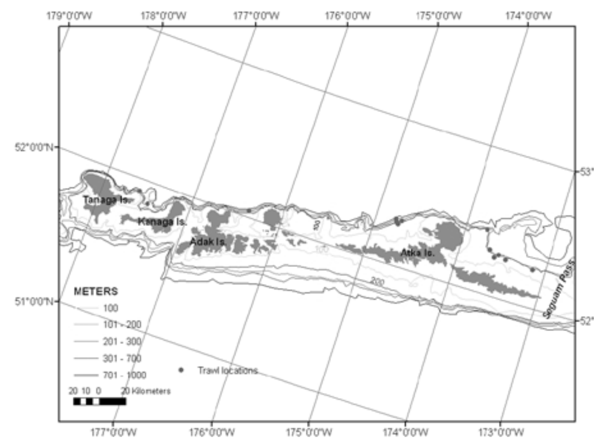

Figure 10. Locations of bottom and midwater trawls conducted during the February 2008 *Oscar Dyson* cruise

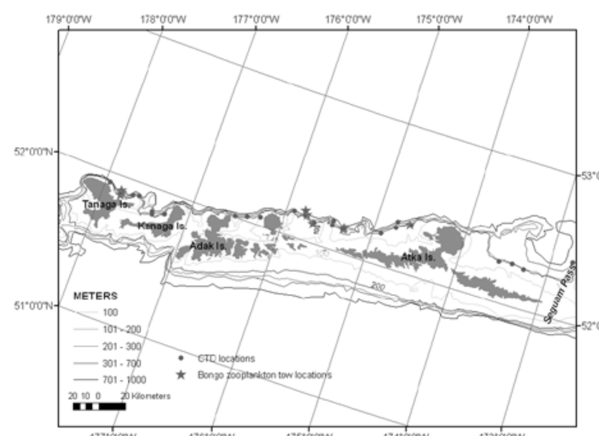

Figure 11. Locations of CTD casts and Bongo zooplankton tows conducted during the February 2008 *Oscar Dyson* cruise.

ECHO-INTEGRATION TRAWL

Survey operations were conducted 24 hours per day. The primary echo integration-trawl (EIT) survey operations were conducted during nighttime hours (approximately 12 hours per day). Acoustic data were collected continuously along a series of parallel transects. Transect spacing was 2.5 nautical miles (nmi), except in areas of anticipated high pollock biomass where transect spacing was smaller, at 1.25 nmi. See Figure 9 for transect locations. Daytime activities included making CTD casts, deploying the Bongo net, and conducting additional trawls for biological samples.

Trawl hauls were conducted to identify echosign and to provide biological samples (a.k.a. "verification tows"). Individual pollock from the verification tows were sampled to determine sex, fork length, body weight, age, and maturity. Maturity was determined by visual inspection and categorized as immature, developing, prespawning, spawning, or postspawning. Other acoustic fish targets, primarily Pacific ocean perch (POP), were sampled for sex and fork length. Trawl locations are shown in Figure 10. A total of 14 trawls were conducted during this cruise.

OCEANOGRAPHIC SAMPLING

Conductivity-temperature-depth data and Niskin bottle samples were collected with the vessel's CTD/rosette system. CTD profilers were deployed opportunistically throughout the survey, primarily during the day, at water depths from 100 to 200 m (Fig. 11). Additional CTD casts were made at selected

The *Oscar Dyson* deck crew bringing in a survey trawl.

The *Oscar Dyson* crew deploying the CTD rosette.

areas, shown in Figure 11. In these areas, CTDs were deployed at water depths around 100 to 200 m and around 500 m. A total of 26 CTD casts were made during this cruise. In addition to the CTD oceanographic data, the ship's Scientific Computing System was configured to log data from temperature, salinity, nitrate, and fluorescence sensors.

ZOOPLANKTON SAMPLING

Bongo tows were conducted to 400 m, or 10 m off the bottom, whichever was shallowest. Tows were conducted during the day, at three different depths, if time allowed: shallower than 200 m water depth, between 200 and 400 m, and offshore at 400 m. Bongo tows and CTD casts were made at the same stations whenever possible. Figure 11 shows the location of Bongo tows and CTD casts. A total of nine Bongo tows were made during the cruise.

SEABIRD OPERATIONS

A USFWS seabird observer conducted observations when the vessel was under way. The observer operated from the bridge (on the port side) for several hours at a time during daylight hours. The observer surveyed a total of 1,198 km during 14 survey days. Weather and sea conditions prohibited surveys during portions of most days. On transect, a total of 2,900 marine birds, and 17 marine mammals were recorded. Marine mammals were sperm whale, killer whale, and Dall's porpoise. Twenty-one species of birds were recorded, with five species accounting for 85% of the total. The most abundant birds were whiskered auklets (*Aethia pygmaea*; 35% of total birds), northern fulmar (*Fulmarus glacialis*; 33%), Laysan albatross (*Phoebastria immutabilis*; 5 %), glaucous-winged gull (*Larus glaucescens*; 6%), and common murre (*Uria aalge*; 7%).

MARINE MAMMAL OPERATIONS

Marine mammal observations were conducted over a total of 2,080 nmi. "On effort" marine mammal observations were conducted over 500.4 nmi, resulting in 18 sightings of three different cetacean species: killer whales (5), sperm whales (2), and Dall's porpoise (11). Four of the killer whale sightings were confirmed from photographs to comprise the fish-eating "resident" lineage. One of these groups contained an adult male with distinctly white coloration, and identification photographs revealed a match to a 2001 sighting of a white whale in the central Aleutian Islands. An additional sighting of a single killer whale was recorded, but was not resighted or photographed. Photographs were also obtained from one group of sperm whales, which was notable for containing relatively small animals of

Male killer whale with distinctly white coloration. (Photo taken under NMFS Scientific Research Permit No. 782-1719). Photo by Holly Fearnbach.

varying sizes, indicating that this may have represented a nursery group of females and their young.

For more details on this cruise and other FIT research go to http://www.afsc.noaa.gov/REFM/Stocks/fit/default.php

By Libby Loggerwell

AGE & GROWTH PROGRAM

Tree Rings and Fish Otoliths

The analogy between tree rings and rings in fish otoliths is often used to explain how fish can be aged from otoliths. However, it is often not realized that the methods that have evolved for ageing tree rings can also be applied to otoliths. This realization was clarified when Oregon State University Professor Bryan Black explained the application of "dendrochronology," or the science of ageing from tree rings, in an AFSC seminar and miniworkshop given to the Age and Growth Program. Bryan Black is working with AFSC age readers and the Status of Stocks Program in a collaboration that we hope will eventually assist in the ageing of some difficult to age rockfish species (e.g., shortspine thornyhead and shortraker rockfishes). Among the interesting things brought out in his talks, was how dendrochronology used unusually poor growth years as a kind of barcode to build time chronologies. Impressively, the bristlecone pine chronology extends back nearly 10,000 years. Bryan Black also explained how marine chronologies from rockfish and shellfish (geoduck), can be correlated with those found in mountain trees. These interesting findings broaden our view of the ecosystem in which we live, play, and study.

By Dan Kimura

Estimated production figures for 1 January–31 March 2008. Total production figures were 5,679 with 2,033 test ages and 126 examined and determined to be unageable.

Species	Specimens
Flathead sole	1,080
Northern rock sole	465
Yellowfin sole	317
Bering flounder	58
Kamchatka flounder	112
Walleye pollock	1,334
Rougheye rockfish	652
Shortraker rockfish	199
Dusky rockfish	507
Warty sculpin	683
Yellow Irish lords	272