AUKE BAY LABORATORIES (ABL)

HABITAT ASSESSMENT & MARINE CHEMISTRY PROGRAM

Reduced Ability of Parasitized Juvenile Walleye Pollock To Capture Prey

Juvenile walleye pollock (*Theragra chalcogramma*) harbor the microsporidian parasite *Pleistophora* sp. encysted in the dorsal musculature. The parasite can infect upwards to 26% of the population of foraging juvenile walleye pollock. In laboratory tests, juvenile pollock averaging 11 cm in total length had a reduced ability to capture euphausid prey when the fish had more than five of the encysted microsporidians in their flesh. During 50 predator-prey trials, individual juvenile pollock were observed to determine how many euphausids the fish could consume in 3 hours. The musculature of each fish was then examined for the present of cysts, and the number of prey consumed was regressed against the number of detected *Pleistophora* sp. cysts. Uninfected walleye pollock were able to consume a mean of 58% of their prey during the allotted time. In contrast, pollock with five cysts were only able to consume 35% of their prey in the same time period. This ability to capture prey declined with increasing parasite intensity. The juvenile pollock were of similar lengths, and predator size was not significantly correlated with performance in the tests. Infection with the microsporidian parasite has the potential to reduce the foraging ability of juvenile walleye pollock.

By Adam Moles

MARINE SALMON INTERACTIONS PROGRAM

Predation Impact on Juvenile Salmon by Sablefish in Southeast Alaska

Sablefish (*Anoplopoma fimbria*) and Pacific salmon (*Oncorhynchus* spp.) are important components of marine ecosystems throughout the eastern Pacific Rim and comprise valuable socioeconomic resources to coastal communities. In Southeast Alaska, for example, exvessel commercial values of these species over the past 5 years averaged $27.0 million for sablefish, and $75.7 million for salmon. Because interannual abundances of sablefish and salmon are both highly variable, understanding mechanisms that govern the production of these species, including trophic interactions, may help to explain fluctuations in year-class strength and improve management of these fishery resources. For example, sablefish and immature salmon may compete for food on the continental shelf, age-1+ sablefish moving inshore may prey on juvenile salmon or compete with them for plankton prey as they migrate to sea in summer, and juvenile sablefish may in turn be preyed on by returning adult salmon as they move onshore in summer and fall.

During routine sampling of the coastal epipelagic habitats of Southeast Alaska in 1999, high abundances of age-1+ sablefish were encountered with juvenile salmon. Many of the sablefish sampled for stomach analyses had eaten juvenile salmon. These events were not observed in prior or subsequent years of monitoring during the Southeast Coastal Monitoring (SECM) project. Consequently, we collected sablefish for laboratory studies to determine gastric evacuation rates, and then combined these data with our field observations to estimate predation impact. We also examined juvenile salmon and sablefish abundance data from the SECM 10-year time-series and adult pink salmon (*O. gorbuscha*) harvest data for the northern region of Southeast Alaska to infer relationships with sablefish.

Predation on juvenile pink, chum (*O. keta*), and sockeye (*O. nerka*) salmon was observed for 43%-60% of the estimated 95,328 sablefish in a 500 km^2 area encompassing Icy Strait in June and July 1999. Age-1+ sablefish had each consumed an average of 1.8 salmon; they also preyed on planktonic invertebrates common in juvenile salmon diets, including pteropods, hyperiid amphipods, euphausiids and some gelatinous taxa. Pink and chum salmon constituted 33% and 60%, respectively, of the juvenile salmon eaten, in proportion to their abundance in the surface trawls. Examination of juvenile salmon size frequencies in the catches and in sablefish guts indicated that prey length was typically about one-third of predator length; in July, the biggest month for predation, sablefish tended to select the smaller juvenile chum salmon available, were not size selective of juvenile pink salmon, and could consume sockeye salmon that were up to 53% of their body length.

In the laboratory, we fed individual sablefish a whole, thawed, previously-frozen juvenile chum salmon in flow-through experimental tanks that simulated summer temperatures of 7° and 12°C. We

sacrificed predators at predetermined time intervals (0.5-96 hours) to model the percent decline in prey biomass over time. Instantaneous evacuation rates, *r*, from the exponential model were -0.027 at 7°C and -0.049 at 12°C. Using these evacuation rates to derive meal frequency, we estimated that the age-1+ sablefish population in the study area consumed 1.13 - 2.77 million juvenile salmon in the summer of 1999. Further, our trawl catch data for the same area indicated that 1999 was an anomalously high year of age 1+ sablefish abundance, an unusually low year for juvenile salmon abundance, and was followed by an extremely low adult pink salmon harvest in the year 2000. These results suggest that sablefish predation on juvenile salmon can be an important ecological interaction, and that strong sablefish year classes may impact salmon survival.

By Molly Sturdevant, Joe Orsi, and Mike Sigler

Auke Creek Weir Installation Delayed by Weather

The key to all fisheries research projects at Auke Creek is the fish counting weir. Auke Creek weir is made operational in early March each year for counting seaward migrating salmonids leaving the Auke Creek -Auke Lake drainage. The 45-year biological data set provides important information about the freshwater life history stages and marine survivals of seven species of anadromous species that migrate in and out of this drainage system, as well as time series data for analysis of climate change and indices for salmon harvest management programs of the Alaska Department of Fish and Game (ADF&G). The weir is operated on a cooperative basis with the University of Alaska School of Fisheries and Ocean Sciences and the ADF&G. Both of these agencies conduct specific research projects on one or more species that migrate through Auke Creek weir. The weir is a permanent structure with the capability of capturing all downstream and upstream migrants, and it is designed to operate even during extreme water flows.

Auke Creek weir was installed in the downstream capture mode on 9 March 2007 during the worst weather in the history of the March weir installations at Auke Creek. Installation was delayed about a week because of low air and water temperatures, but nonetheless occurred during a blizzard. Five feet of snow covered the ground when the weir was installed (Fig. 1). Weir traps were buried and were lifted out of the snow with a hydraulic crane. Stream flow was low; however, the weir was operating within a few hours of installing the last stop logs. Stream flow remained low throughout the month, and only three of five fry traps were operated during the month. Decreasing air temperatures during the last week of March resulted in the accumulation of ice on the weir traps, collection trough, and holding tank. The weir pool was frozen over for several days, but not to the extent seen in 2006. Auke Lake remained ice covered throughout March, and water temperatures were between 0.4° and 0.9°C.

Pink and chum salmon fry usually dominate the number of emigrants captured at Auke Creek weir during March, with an occasional Dolly Varden char or cutthroat trout being captured. The March 2007 migration of pink salmon fry at Auke Creek is one of the lowest on record. The daily counts were less than average for the entire month of March, and a total of only 805 pink salmon fry were counted at the weir through March. For comparison, the average number of pink salmon fry leaving Auke Creek during the last 3 weeks in March is 10,000 with a range in March pink salmon emigrations of 135

Figure 1. Auke Creek weir and hatchery 7 March 2007 before weir installation. Stream flow was low, air and stream temperatures were near record lows, and there was 5 feet of snow on the ground. Photo by Jerry Taylor.

(1979) to 45,000 (1984). The highest daily count for March 2007, 121, (30 March) is an order of magnitude lower than the historical average daily count of 1,000 pink salmon fry. Chum salmon fry, 308 total, were the only other species caught during March 2007.

Low numbers of emigrants in March do not necessarily portend a small 2007 emigration, as the pink salmon fry emigration this year is expected to be later than in recent years. Based on average stream temperature from August 2006-March 2007 the predicted midpoint of pink salmon emigration is 28 April. The average midpoint of emigration for pink salmon at Auke Creek is 20 April, and latest midpoint of emigration is 7 May 1982.

By Jerry Taylor

MARINE ECOLOGY & STOCK ASSESSMENT PROGRAM

Pacific Salmon Commission Northern Fund Projects

Two proposals designed to assist NOAA's National Marine Fisheries Service (NMFS) in assessing and managing essential fish habitat (EFH) in Alaska's coastal areas were accepted for funding by the Pacific Salmon Commission. The studies focus on fish habitat dynamics in large glacial rivers. These projects are joint efforts involving personnel from ABL and ADF&G. One study will assess spatial and temporal patterns of fish distribution in relation to environmental factors found in the Taku River estuary. The other project is designed to integrate historical and recent physical habitat and fish distribution information to evaluate habitat changes in the lower Taku River watershed. Field work on the estuary project will commence in early May and be complete by late August. Work on the analysis of habitat change in the Taku watershed will focus this summer on geo-referencing existing imagery and habitat mapping data to compare to new imagery that will be acquired in fall 2007 and spring 2008.

By Mitch Lorenz

Sablefish Workshop

Sablefish symposia were held in 1983 and 1993 and brought together scientists to share information and discuss future needs of sablefish research in the North Pacific. In 2004, a meeting was called at the Western Groundfish Conference to discuss formation of a sablefish working group which would work to organize a third sablefish symposium. Because of conflicting assignments and schedules of scientists working on sablefish, this symposium has been delayed. However, an interim, informal sablefish workshop was organized and held 21-23 February 2007 at the AFSC in Seattle. The purpose of the workshop was to bring together Alaska, British Columbia, and West Coast sablefish assessment scientists to a small informal roundtable workshop to exchange information and knowledge, identify new research directions and needs, and investigate cooperative research opportunities.

Twelve participants attended the meeting representing the AFSC, Northwest Fisheries Science Center, ADF&G, Fisheries and Oceans Canada, Sigma Plus Consulting, and Simon Fraser University. Each agency provided general overviews of the sablefish stocks in their region. Roundtable discussions were held focusing on specific agenda topics including stock assessment, survey methodologies, life history parameters, harvest strategy evaluations, and recruitment processes. The group recommended future collaborative work among sablefish scientists to better understand sablefish migration and assessment. A workshop summary is being prepared for distribution to the Canada-U.S. Groundfish Technical Subcommittee and the North Pacific Fishery Management Council's Plan Teams.

By Chris Lunsford

OCEAN CARRYING CAPACITY PROGRAM

Effects of Consumer Size and Two Types of Zooplankton Prey on the Functional Response of Juvenile Pink and Chum Salmon

Feeding rate experiments were conducted for pink salmon (*Oncorhynchus gorbuscha*) fry (mean fork length (FL) 39 mm), juveniles (103-104 mm FL), and juvenile chum salmon (*O. keta*; 106-107 mm FL). Fishes were presented with small copepod (*Tisbi* sp.) or larger mysid shrimp (*Mysidopsis bahia*) prey at varying densities ranging from 1 to 235 prey/liter in feeding rate experiments conducted at water temperatures ranging from 10.5° to 12.0°C under high light levels and low turbidity conditions. Both salmon species demonstrated type II functional responses to zooplankton prey. When offered copepods, pink salmon fry fed at a higher maximum

consumption rate (2.5 copepods/min) than larger juvenile pink salmon (0.4 copepods/min), whereas larger juvenile chum salmon exhibited the highest feeding rate (3.8 copepods/min). When feeding on mysids, the maximum feeding rate for larger juvenile pink (12.3 mysids/min) and chum (11.5 mysids/min) salmon were similar, and higher than feeding rates on copepods. Functional response models parameterized for specific sizes of juvenile salmon and zooplankton prey can offer insight into the mechanistic limitations and prey preferences on planktivorous fish consumption rates given biological and physical conditions experienced by the fishes.

By Jamal Moss

Does Size Affect Survival Rates in Juvenile Sockeye Salmon?

We tested the hypothesis that larger juvenile sockeye salmon in Bristol Bay, Alaska, have higher marine stage survival rates than smaller juvenile salmon. The data consisted of archived scales from returning adults (33 years of data) and trawl samples of juveniles (n = 3,572) collected along the eastern Bering Sea shelf during August through September 2000-02. The size of juvenile sockeye salmon mirrored indices of their marine stage survival rate (i.e., smaller fish had lower indices of marine stage survival rate). However, there was no relationship between the size of sockeye salmon and marine stage survival rate after their first year at sea, as estimated from archived scales and brood year survival; size was relatively uniform over the time series, possibly indicating size-selective mortality on smaller individuals during early marine residence. Variation in size, relative abundance, and marine stage survival rate of juvenile sockeye salmon is likely related to ocean conditions affecting their early marine migratory pathways along the eastern Bering Sea shelf.

By Ed Farley

FISHERIES MONITORING & ANALYSIS (FMA) DIVISION

Huge Shortraker Rockfish Delivered to FMA Wet Laboratory

Observers identify and collect biological information from various species found in the Bering Sea/Aleutian Islands and Gulf of Alaska during their deployments. The majority of the biological data collected falls well within the expected size ranges and species distributions for a particular area. On occasion, something different is found in the catch. This quarter, a particularly interesting specimen was delivered to Fisheries Monitoring and Analysis Division (FMA). Michael Myers, the factory manager of the catcher processor trawl vessel *Kodiak Enterprise*, delivered a huge shortraker rockfish (*Sebastes borealis*) (Fig. 1) that had been caught by the vessel north of Unalaska Island.

Shortraker rockfish are the largest rockfish of the genus *Sebastes* found in Alaskan waters. The maximum length reported for shortraker rockfish in the North Pacific Ocean is 120 cm fork length. It is estimated that the species reaches maturity at 9 – 12 years. The species has been aged up to 157 years and is among the longest-lived fishes in the oceans.

This particular fish was caught in a pelagic trawl targeting walleye pollock in approximately 350 fathoms (640 m) of water. The specimen weighed 26.7 kg, was 112 cm long, was female, and held eggs in the late developing stage (vitellogenesis). The gonads and stomach were collected by the AFSC Fishery Interaction Team for later analysis. The otoliths were removed for analysis by the AFSC Age and Growth Program; their work on this specimen is also addressed below.

Mr. Myers spotted the shortraker rockfish among the catch of pollock along with other large, but not quite as large, red rockfish. (These fish were dead when brought on deck.) The specimen was not part of the observer's sample so Mr. Myers collected the specimen himself. After taking the rockfish to

Figure 1. AFSC scientist Chris Wilson with shortraker rockfish and 38-inch ruler in the FMA wet lab. Photo by Karna McKinney.

Figure 2. Observers and UW graduate student identify fish in the FMA wet lab. Photo by Brian Mason.

his children's school where it delighted both students and faculty, Mr. Myers brought the fish to the FMA wet lab for our use. Many AFSC staff members enjoyed the opportunity to view this unusually large specimen.

Specimens brought in by observers and the fishing community support the FMA teaching collection. The FMA collection of fish, crab, and bird specimens is essential to the observer training program. The FMA Division and the University of Washington (UW) collaborate in training; the UW has provided graduate students to conduct species identification training and curate the teaching collection (Fig. 2). This arrangement provides quality fish identification training for observers through lectures on key identification characteristics and laboratory sessions with the trainer. Initial training and periodic follow-up briefings include species identification exercises to ensure observers are skilled in specimen identification and in recognizing when a specimen should be brought to the lab for verification and documentation.

Unique, rare, or out-of-range specimens brought to us are identified through the combined expertise of AFSC and UW staff. These specimens are often added to the UW Fish Collection where over 500 specimens representing 189 species collected by observers are cataloged. Further information the UW Fish Collection is available on the web at *http://artedi.fish.washington.edu/*. Two specimens collected by observers were an important contribution to recent research at the UW on deep-sea anglerfish (suborder Ceratioidei). One of these specimens was a rarely seen female with an attached male. Additionally, observer collected specimens have contributed to range extensions of North Pacific fishes such as Aleutian scorpionfish (*Adelosebstes lateens*) and gray rockfish (*Sebastes glaucus*).

Time spent at sea provides observers and fishers alike with unique opportunities to collect specimens that contribute to the knowledge of the fish, crab, and birds that inhabit the Bering Sea/Aleutian Islands and Gulf of Alaska regions. Through our working relationship with the UW, FMA provides observers the training to recognize and collect needed specimens contributing to our overall scientific knowledge. This work is supplemented through helpful contributions from members of the fishing industry as noted above.

By Allison Barns

NATIONAL MARINE MAMMAL LABORATORY (NMML)

ALASKA ECOSYSTEMS PROGRAM

Marine Science in Alaska Symposium

The Alaska Marine Science Symposium was held 21-24 January 2007 in Anchorage, Alaska. Vladimir Burkanov, Brian Fadely, Lowell Fritz, Tom Gelatt, Michelle Lander, Mary-Anne Lea, and Rolf Ream from the Alaska Ecosystems Program gave oral and poster presentations on the distribution, abundance, and foraging ecology of northern fur seals and Steller sea lions. The symposium was sponsored by 21 different organizations, agencies, and universities including the Alaska Fisheries Science Center (AFSC) and the North Pacific Research Board. The symposium focused on a variety of topics pertaining to the climate, oceanography, and animals of the Arctic Ocean, Bering Sea, Aleutian Islands, and Gulf of Alaska.

At the symposium, Fadely convened a formal Steller sea lion research coordination meeting with all research permit holders to discuss the coordination, collaboration, and dissemination of information among Steller sea lion researchers. The meeting also included a briefing from NMFS officials regarding permit issues relative to the time line of the Programmatic Environmental Impact Statement for Steller sea lion and northern fur seal research.

The Draft Programmatic Environmental Impact Statement (DPEIS) consists of a programmatic analysis of current and future research projects that are funded and permitted through the federal government, and it evaluates the potential impacts of research on both species. This DPEIS was available for public comment in the Federal Register from 16 February to 2 April 2007, and one of three public hearings was held at the AFSC on 15 March. Additional information regarding the process and the progress of the DPEIS is available on the web at *http://www.nmfs.noaa.gov/pr/permits/eis/steller.htm*.

By Michelle Lander

Northern Fur Seal Research Update

Juvenile northern fur seal. Photo by Tonya Zeppelin.

In the October-December 2006 issue of the AFSC Quarterly Report, we reported on the winter migration routes of young northern fur seals tagged with satellite transmitters. As of this writing, tags on 20 of the 30 juveniles and 27 of the 47 pups are still transmitting. Similar to previous results, all of the juveniles (with the exception of one individual) are still south of the Aleutian Islands chain, and the pups remain dispersed throughout the North Pacific and Bering Sea.

By Michelle Lander

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

Gray Whale Census in 2006/07

Gray whales (*Eschrichtius robustus*) have a phenomenally routine migration along the western coast of North America. The southbound migration was documented by Cetacean Assessment and Ecology Program (CAEP) observers from 12 December 2006 to 22 February 2007 (Fig. 1) in a manner comparable to previous surveys (see below). Lone observers independently recorded sighting and environmental data during three 3-hour watches each day in small sheds on the edge of a 22-m sea cliff at Granite Canyon in central California. The counting system and observer performance were tested through paired, independent observational effort, as has been done each census since 1985/86. In addition, the Southwest Fisheries Science Center (SWFSC) conducted an independent effort in a nearby trailer, using a team of two observers (one dedicated to searching, the other both searching and typing in data) that rotated through 1.5-hour (h) watches for 9 h each day from 2 to 27 January. These counts will serve as a comparison to the standard effort by CAEP observers because the SWFSC will be conducting the gray whale census in the future.

A fix-mounted, high-powered (25X) binocular provided an index of the offshore distribution of migrating whales passing within the sighting range of the observers. The timing of the 2006/07 southbound migration seemed to be 1 week later than in previous years, with the median date close to 21 January instead of 15 January. Most (80%) of the sightings occurred in January, 17% were in February, and only 3% were in December. There were 1,770 pods of whales counted during the 73 days (651.6 h) of the standard census during fair to excellent visibility conditions. This summary count compares favorably with similar counts from 2000/01 (1,684 pods in 599.4 h) and 2001/02 (1,712 pods in 531.5 h). Population abundance calculations from the observer counts will follow the same analytical approach applied in previous studies. These methods

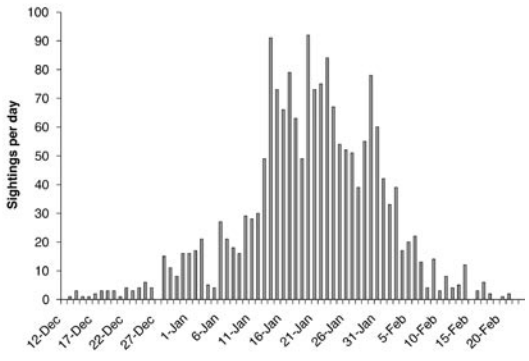


Figure 1. Gray whale sighting rates throughout the southbound migration past Granite Canyon in central California, 12 December 2006 to 22 February 2007.

account for 1) whales passing during periods when there is no observational effort (prior to and after the census season, at night, or when visibility is poor); 2) whales missed within the viewing range during on-effort periods; 3) differential sightability by observer, pod size, distance offshore, and various environmental conditions; 4) errors in pod-size estimation; 5) covariance within the corrections due to variable sightability by pod size; and 6) differential diel travel rates of whales.

By David Rugh

Beluga Conference in Valencia, Spain

With many institutions across the world displaying live beluga whales for research and educational purposes, and six polar countries managing wild beluga populations, there is an increasing need for communication and information sharing to further beluga whale conservation. In order to foster collaborations in research and husbandry practices, L'Oceanogràfic of Valencia, Spain, hosted the First International Workshop on Beluga Whale Research, Husbandry, and Management in Wild and Captive Environments, from 9 to 11 March 2007.

The workshop was the first directed effort at bringing people together who work with beluga whales, either in captivity or in the wild, to review the current state of knowledge, determine research needs, and build a coordinated effort to better conserve and understand these charismatic animals. Participants in the workshop identified topics for research in aquaria that would be advantageous for conservation of belugas in their natural habitats and discussed how research results from wild beluga populations could enhance the well-being of captive belugas.

NMML representatives at the conference presented posters on: 1) "Habitat use of beluga whales in Cook Inlet Alaska," detailing the last 3 years of habitat analyses by applying advanced ecological modeling techniques as a means to better understand beluga distribution and habitat preferences; 2) "Using advanced techniques to determine age categories of belugas," which applied digital imagery to better differentiate calves, juveniles, and adults in aerial photographs and video; and 3) "Cook Inlet beluga population: failure to thrive?" which presented a review of recent research and discussed future research needs and interests, including studying comparable wild populations and captive animals.

Overall, this workshop was a huge first step towards beluga conservation. Not only are belugas an important component of the arctic ecosystem, but they also are an ideal species for learning about climate change and ecosystem fragility. This workshop was a catalyst to promoting cross-cultural understanding and collaboration among stakeholders around the world.

By Kimberly Goetz and Rod Hobbs

Winter Whale Surveys in Kodiak, Alaska

From 5 to 12 February 2007, Sally Mizroch (Cetacean Assessment and Ecology Program) collaborated with seabird researcher Denny Zwiefelhofer (Kodiak National Wildlife Refuge) to conduct opportunistic photo-identification and biopsy studies of whales during winter seabird surveys in western Kodiak, Alaska. Zwiefelhofer has been opportunistically observing marine mammals during systematic winter seabird and sea duck surveys conducted each year since 1980. His humpback whale data have been integrated into the NMML North Pacific humpback whale database and various Kodiak-area humpback whale photo-identification catalogs, and his fin whale data will be included in a paper (by Mizroch et al.) documenting the distribution and movements of fin whales in the North Pacific Ocean.

During the February 2007 survey of western Kodiak waters, seven individual humpback whales and nine individual fin whales were identified, and biopsies were collected from five humpback whales and two fin whales (Fig. 2).

The presence of cookie cutter shark, *Isitius brasilensis*, scars on the photographed fin whales confirmed that the wintering fin whales were migratory, not resident (Fig. 3). Since the distribution of cookie cutter sharks does not include waters north of the northern limits of the subarctic boundary (lat. 38°N), these fin whales have spent time in waters south of the boundary. However, the low latitude migratory destinations of these western Gulf of Alaska fin whales are unknown.

Humpback whale photo-identification data confirmed that many of the photographed humpback whales had been seen by Zwiefelhofer in Kodiak waters in previous years, including one whale that was seen during summer months in both Kodiak (D. Zwiefelhofer, unpublished data) and the Shumagin

Figure 2. A humpback whale photographed in Uganik Bay, Kodiak, as it was being biopsied. Photo by Sally Mizroch.

Figure 3. A fin whale with cookie cutter shark scars, photographed in Uyak Bay, Kodiak. Photo by Sally Mizroch.

Figure 4. A humpback whale photographed in February 2007. This whale had been photographed previously in summer months in Kodiak and the Shumagin Islands. Photo by Sally Mizroch.

Islands (B. Witteveen, unpublished data) (Fig. 4). If these whales follow the same pattern found in Southeast Alaska, we can assume that they are feeding on overwintering forage fish before migrating south to one of the low-latitude concentration areas. Based on photo-identification data in the NMML North Pacific humpback whale database, humpback whales from the Kodiak region have been seen in Hawaii and in all regions of Mexico (mainland Mexico, Baja California, and offshore), and humpback whales from nearby areas (eastern Aleutian Islands, Shumagin Islands) have been photographed in Japan as well.

By Sally Mizroch

POLAR ECOSYSTEMS PROGRAM

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 are 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 2007, the Polar Ecosystems Program (PEP) will conduct research on seals in the sea ice of the Bering Sea during two multidisciplinary cruises aboard the U.S. Coast Guard icebreaker *Healy* and one dedicated cruise on the NOAA Fisheries research vessel *Oscar Dyson*. Our teams' main objectives will be to capture ice seals (most likely ribbon seals and spotted seals) and instrument them with satellite-linked data recorders (SDRs). The SDRs are used to provide information on an animal's diving behavior and movements. In addition, we will conduct visual surveys of marine mammals from each vessel and aerial surveys from the helicopter that will be available on the *Healy*.

In all, 15 people will participate on the PEP research teams. Four 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 the PEP during January-March 2007.

By Peter Boveng

RESOURCE ASSESSMENT & CONSERVATON ENGINEERING (RACE) DIVISION

GROUNDFISH ASSESSMENT PROGRAM

Working Group for Bottom Trawl Survey Improvements Reducing Error in Area Swept Estimates

In January 2006, the Groundfish Assessment Program (GAP) formed the Working Group for Bottom Trawl Survey Improvements (WGBTSI) to assess the GAP survey methodology in the context of the best available science. The primary goal of the WGBTSI is to critically review GAP bottom trawl surveys and to make recommendations for reducing systematic errors in survey procedures and data analyses. From January to March 2007, the group focused on reviewing the components of the area swept calculation used for estimating catch per unit effort (CPUE), specifically the methods for calculating the average width and distance traversed by the trawl net.

Currently the GAP uses two different methods for calculating distance fished. The eastern Bering Sea shelf trawl survey estimates the beginning and end points of the towpath and calculates the straight-line distance between the two. All other GAP surveys estimate distance using a moving average of the actual path of the trawl tow. GAP scientist Michael Martin modeled the effects of curved bottom trawl tows and noisy global positioning system (GPS) data on distance fished calculations. Model simulations showed that systematic error could be introduced with curved or noisy towpath data when using a moving average or a simple exponential smoother to calculate distance fished. A cubic spline method, however, produced very little systematic error and was least affected by noisy or curved GPS data.

The GAP calculates average net widths using a simple mean of the acoustic net spread observations obtained from the trawl net mensuration equipment. Similar to GPS data, acoustic net spread data can be noisy, and unrealistic measurements must be filtered prior to averaging. Filtering is currently done using a standard range of netspread values that assumes outliers are symmetrical around the mean. GAP scientist Stan Kotwicki analyzed net spread data from the 2006 eastern Bering Sea bottom trawl survey and found that outlier data are not consistently symmetrical and that simply applying arbitrary bounds on net spread data can cause a systematic bias in net width averages. To minimize potential bias caused by selectively gating raw net spread data, Kotwicki is developing a more robust method of outlier rejection using sequential rejection. The method iteratively removes outliers and fits a cubic spline smoother (the same smoother used in the distanced fished calculations) to the remaining data in an attempt to eliminate bias in the resulting calculation of mean net spread.

A third area of interest within the WGBTSI was changes in trawl performance and catching efficiency during the retrieval period of Bering Sea survey trawl. When winches are engaged at haulback, the speed over ground of the trawl increases and there is a lag period before the trawl net is completely off bottom. The time lag duration can vary with the depth of tow and the skipper operating the vessel. During this period, the trawl performance is different and the net is catching at less than 100% efficiency. Increased speed also increases the distance traversed by the trawl relative to distance covered by the vessel. The WGBTSI is currently discussing ways estimate and model biases associated with the retrieval period.

By Bob Lauth

Passive Acoustics to Study Spawning Essential Fish Habitat

Fishery scientists and managers are mandated by the Magnuson-Stevens Fisheries and Conservation and Management Act (MSFCMA) to identify and describe, both in a spatial and temporal sense, those waters and substrate necessary for spawning. In the context of the new paradigm for an Ecosystem Approach to Management, it is surprising that such basic life history information is lacking for many important commercial fish species in Alaska, and that managers are tending to focus more on the "big picture" while neglecting basic areas of research.

For marine fishes in Alaska waters, the relatively new and rapidly emerging field of passive acoustics has tremendous potential for studying spawning essential fish habitat (EFH). What is passive acoustics? In the September 2006 issue of *Fisheries*, Rountree et al. define passive acoustics as "the act of listening to the sounds made by fishes and using that information as an aid in locating fish so that their habitat requirements and behaviors can be studied." In the North Pacific, fishery managers and funding agencies are unfamiliar with this technology. They will need to be educated and convinced that Alaska fishes make sounds and that there are useful management applications using passive acoustics. A first step will be to determine which Alaska groundfish species actually make sounds, and then associate those species-specific sounds to behaviors such as courtship, mating, feeding, or aggression.

From 7 to 9 February, Bob Lauth attended a workshop on Underwater Passive Acoustic Monitoring for Remote Regions. The workshop was sponsored by the Alliance for Coastal Technologies (ACT) and was conducted at the Hawaii Institute of Marine Biology. The workshop provided an opportunity to meet other research scientists in the field and learn more about the passive acoustic tools being used. By collaborating with scientists and technology developers, Lauth was able to build a low cost (<$1,000) underwater passive acoustic device for listening to fish. He is currently working with the RACE Fisheries Behavioral Ecology Program in Newport, Oregon, and the Alaska SeaLife Center in Seward, Alaska, to record fish sounds both in situ and in the laboratory.

By Bob Lauth

Skate Nurseries Research in Eastern Bering Sea Produces New Ph.D.

On 26 January 2007, Gerald Hoff successfully defended his Ph.D. entitled "Reproductive Biology of the Alaska Skate *Bathyraja parmifera*, with Regard to Nursery Sites, Embryo Development and Predation." Hoff's research focused on characterization of an Alaska skate nursery site located in the southeastern Bering Sea, where he identified the extent of the nursery and its habitat, and included seasonal sampling to determine the timing of reproduction and egg deposition; timing of embryo hatching; and mortality sources to young skates.

The findings showed that the nursery site was small in area (<2 km^2) and contained egg cases at very high densities throughout the year. Reproduction was seasonal with peak deposition events in the summer months (June-August) and low levels of egg deposition throughout the year. Embryo development time, from deposition to hatching, was protracted and estimated to be more than 3 years. Mortality sources to young skates included snails and large predatory fishes. Snails drilled holes in newly deposited egg cases and devoured the large yolk, and predatory fishes including Pacific cod (*Gadus macrocephalus*) and Pacific halibut (*Hippoglossus stenolepis*) consumed newly hatched juvenile skates in the nursery area.

To date, seven nursery sites for three different Alaskan skate species have been located in the eastern Bering Sea. All nurseries were quite small in area, were composed of a single species, and possessed high densities of egg cases. Sites were near canyon heads along the shelf-slope interface between 150 and 380 m. Upwelling along the upper slope and shelf break is highly productive, and nearly constant water temperatures year-round provide an optimal environment for successful embryo development and hatching. Mature adults utilized the nurseries primarily for reproduction. Immature, juvenile and newly hatched skates were relatively rare within nursery sites.

This research has broad implications for identification of essential fish habitat for these slow growing, late maturing, and low fecund fish species. The findings from this study will be incorporated into conservation strategies for elasmobranch species in the North Pacific as management plans are developed. The North Pacific Research Board and the AFSC supported this research.

By Gerald Hoff

Groundfish Research and Analysis

Dr. James (Jay) Orr accepted an invitation to serve as Visiting Professor and Research Scholar of Kyoto University in Japan for the January to March quarter. He has been working with Japanese ichthyologists and examining fish specimens for several projects on the systematic taxonomy of North Pacific fishes. His research has included work on the rougheye and blackspotted rockfishes (with Sharon Hawkins, ABL), the description of a new species of skate from the Aleutian Islands related

to the Alaska skate (with Duane Stevenson, Gerald Hoff, and John McEachran of Texas A&M), and the taxonomy of North Pacific sand lance (with Y. Kai of Kyoto University). Because important specimens are archived in several collections around Japan, he has spent several weeks traveling to facilities in other parts of the country, including Kyoto University's Fisheries Research Station in Maizuru, Hokkaido University's Faculty of Fisheries Museum of Zoology in Hakodate, and the National Science Museum in Tokyo.

Dr. Duane Stevenson is assisting Alaska Sea Grant in the final preparation of a "Field Guide to the Cartilaginous Fishes of Alaska" to be published this summer. He is also continuing preparation of a manuscript describing patterns of distribution and abundance in the skates of Alaska and another revising the zoarcid genus *Bothrocara* (with E. Anderson of the South African Institute for Aquatic Biology).

By Jay Orr

Bottom Trawl Survey Staff Meets with NWFSC and Canadian Colleagues

For the past 4 years, AFSC bottom trawl survey staff has met annually with colleagues from the Northwest Fisheries Science Center (NWFSC) and the Canadian Department of Fish and Oceans (Pacific Biological Station, Nanaimo, B.C.) who do comparable groundfish research operations at their respective agencies. The working group was instigated under the auspices of the Technical Subcommittee of the Canada-U.S. Groundfish Committee and affords survey scientists from these agencies the opportunity to regularly compare methods, survey designs, and recent developments in the science behind fishery-independent trawl surveys of groundfish and invertebrate resources in the North Pacific and eastern Bering Sea.

AFSC scientists hosted the 2007 meeting on 20 February. AFSC scientists presented a summary of work done to improve measurement of survey trawl effort (distance fished and net width) and summarized progress on a project to investigate how inclusion of rocky or otherwise severe bathymetric portions of the survey area inaccessible to standard bottom trawls may bias stock assessments. NWFSC scientists reported on their current West Coast survey sampling scheme, described updates to the equipment and software used to record and analyze data, and summarized research on the impact of sea state on trawl survey catches. Canadian scientists reviewed their overall strategy of the suite of surveys they conduct off British Columbia, presented a recent business review of their Queen Charlotte Sound bottom trawl survey, and discussed implications of a decision regarding selling fish caught during research charters to help defray the cost of the research programs.

By Mark Wilkins

Ergonomics of At-Sea Sampling Assessed

The Groundfish Program's Safety Committee, which has expanded to include seagoing staff from the Resource Ecology and Fisheries Management (REFM) and Fisheries Monitoring and Analysis (FMA) Divisions, organized an ergonomic assessment of the typical work conditions for sampling catches aboard charter vessels used to conduct bottom trawl surveys. On 15 March, a mock deck set up–complete with tables used for sorting, weighing, and collecting specimens and data from fish and invertebrates and all of the sampling equipment routinely used during operations at sea–was used for the ergonomic assessment. Ergonomics specialist Joe Duran (NOAA Regional Safety Manager) was shown the typical workflow of sampling trawl catches during the surveys, including all the tools and tasks that field scientists are required to perform. The demonstration was informative and at the next meeting, Joe will provide the Safety Committee his assessment of improvements that should be considered to the workflow, equipment, and task assignment protocols that could improve the safety and well-being of our field staff aboard the vessels.

By Mark Wilkins

Presentations

Brian Knoth and Chris Rooper of the Groundfish Program each presented a poster (in absentia) at the Alaska Marine Science Symposium held in Anchorage from 21 to 24 January. (See the AFSC Poster database at *http://access.afsc.noaa.gov/pubs/posters/poster_search.cfm*.)

Brian's poster was entitled "Arrowtooth flounder (*Atheresthes stomias*) diet and prey consumption near Kodiak Island, AK". The research examined temporal (interannual and within-year), spatial, and ontogenetic differences in the diet and prey consumption of the nearshore arrowtooth flounder (ATF) population. The study highlighted the adaptable feeding behavior of ATF and provided baseline data con-

cerning the magnitude of ATF prey consumption near Kodiak. This work was conducted in collaboration with Dr. Robert Foy of the University of Alaska Fairbanks.

Chris's poster was entitled "Characterizing Trawlable and Untrawlable Substrate Using Single Beam Echo Sounder Data to Improve Estimation of Commercial Groundfish Abundance" (by Rooper, Mark Zimmermann, and Michael Martin). This poster described ongoing efforts by RACE biologists to classify seafloor substrate as trawlable or not trawlable using seabed acoustic backscatter collected during RACE trawl surveys. The analysis used characteristics of the shape of echoes returned from the seafloor and classification tree analysis to determine trawlability of substrate in the Aleutian Islands. The method shows promise for classifying substrate as it modeled trawlability at three transects with >90% acccuracy and was able to predict trawlability at a test dataset with 75% accuracy.

Rooper also presented a different poster at the 50th Anniversary Symposium of the American Institute of Fisheries Research Biologists held 13-15 February in Seattle. This poster was entitled "An ecological analysis of rockfish (*Sebastes* spp.) assemblages in the north Pacific along broad-scale environmental gradients" and described an assemblage analysis of Gulf of Alaska (GOA) and Aleutian Island (AI) bottom trawl data collected on rockfish species in Alaska. The analysis used an index of overlap of species and age groups along environmental gradients to determine differing distributions of rockfish throughout Alaska. The analysis identified four major groups of rockfish separated by both depth and location along the Alaska coastline (a deepwater group in Southeast Alaska, a deepwater group in the central GOA and AI, as well as a mid-depth group in each location).

MIDWATER ASSESSMENT & CONSERVATION ENGINEERING PROGRAM

Miller Freeman and *Oscar Dyson* Intervessel Comparison

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program continued an intervessel comparison of acoustic-trawl survey data collected aboard the NOAA ships *Miller Freeman* and *Oscar Dyson* during the Bogoslof and Shelikof Strait surveys. The primary goal of this work is to investigate if walleye pollock differentially avoid the *Oscar Dyson,* which was designed to meet the ICES specification for underwater radiated noise to minimize vessel avoidance during fish abundance surveys, and the *Miller Freeman*, a conventionally built vessel which exceeds this specification. It is possible that fish will respond differently to the vessels due to the disparate auditory stimuli produced by each vessel. If this is the case, differential vessel avoidance may influence the biomass estimates derived from standard survey methods with the two ships. This is of particular interest for resource management in Alaska waters as the *Oscar Dyson i*s scheduled to become the primary vessel for walleye pollock acoustic-trawl surveys, which have historically been conducted aboard 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, which was developed and implemented by MACE staff, consisted of a component in which the vessels traveled side-by-side at a distance of 0.7 nautical miles (nmi) along survey tracklines, which allowed for standard survey operations without compromising the data for use in stock assessment, and a component in which one vessel followed the other at a distance of 1 nmi. 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. Analysis of these data is in progress. Further fieldwork comparing the two vessels is planned for the winter and summer of 2008.

Winter Surveys in Gulf of Alaska and Southeastern Bering Sea Near Bogoslof Island

MACE scientists conducted winter echo integration-trawl surveys aboard the NOAA ship *Miller Freeman* in the Gulf of Alaska (GOA) and southeastern Bering Sea near Bogoslof Island. The surveys provide data on the abundance, distribution, and biological composition of spawning walleye pollock (*Theragra chalcogramma*). Areas surveyed in the GOA between 6 and 14 February included the Shumagin Islands, Sanak Trough, and Morzhovoi Bay (Fig. 1), and between 11 and 29 March included the Shelikof Strait area, Chirikof shelf-break area, and Marmot Bay (Fig. 2).

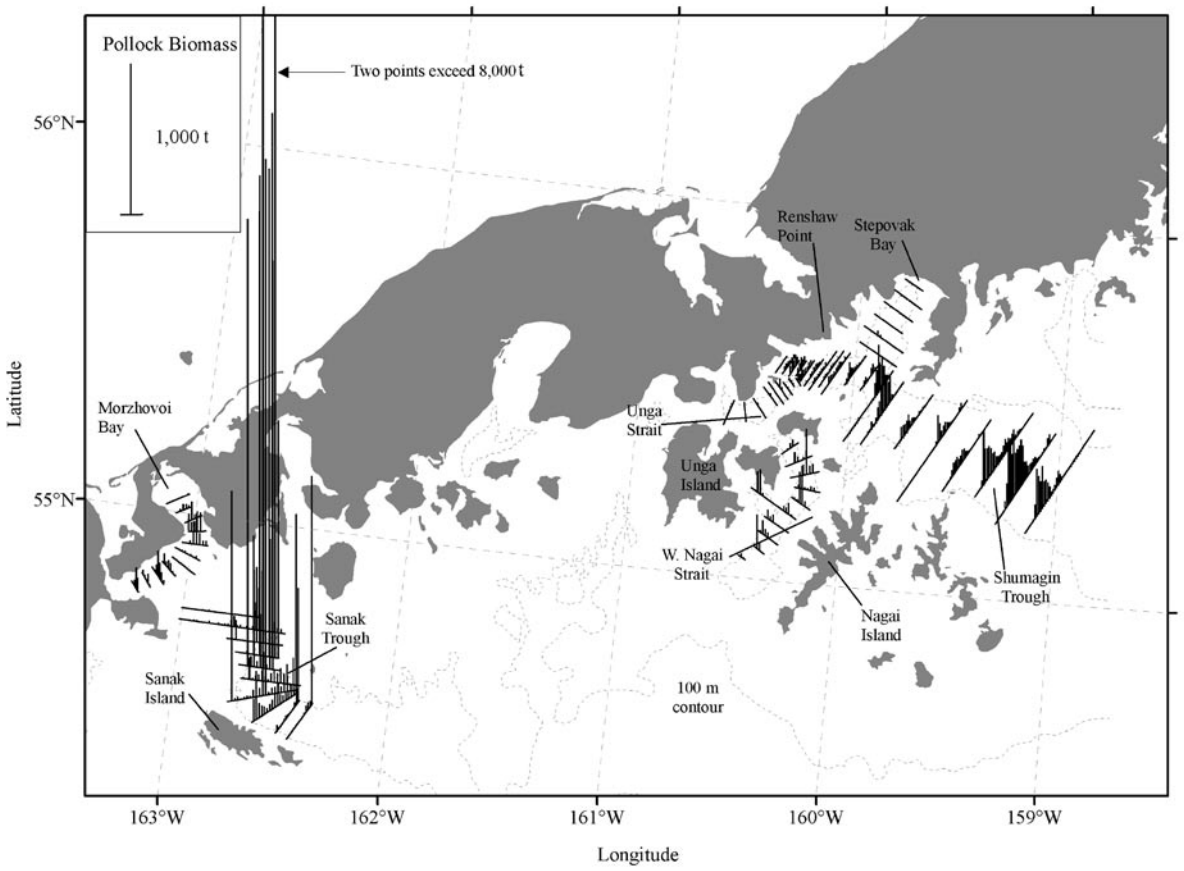


Figure 1. Estimated walleye pollock biomass in metric tons (t) (vertical lines) along transects during the 6-14 February 2007 echo integration-trawl surveys of the Shumagin Islands, Sanak Trough, and Morzhovoi Bay in the Gulf of Alaska.

The area in the vicinity of Bogoslof Island in the Bering Sea was surveyed from 1 to 10 March (Fig. 3). All surveys were conducted 24 hours per day.

The GOA survey results indicated that walleye pollock abundance decreased in 2007 compared to 2006 in all areas. Nevertheless, localized dense adult walleye pollock aggregations were observed in some of the surveyed areas. The densest aggregations were located in the northern part of Sanak Trough and relatively high fish densities were detected in Shumagin Trough, along the eastern portion of the Chirikof shelf-break near the mouth of Barnabas Trough, and in the southern end of the Shelikof Strait proper. In Marmot Bay, which was surveyed for the first time this year, the highest densities were located in the western end of the bay.

Walleye pollock size compositions for Sanak Trough, Morzhovoi Bay, and Chirikof shelf-break GOA surveys were unimodal, with most fish between 50 and 60 cm fork length (FL). In the Shumagin Islands and Marmot Bay, age-1 (11 to 12 cm FL modes) and age-2 (19 to 22 cm FL modes) fish dominated the size compositions. In Shelikof Strait the size composition was broadly distributed, with age-1 (12 cm FL), age-2 (21 cm FL), age-3 (30 cm FL) and adult length modes (53 cm FL). Preliminary analysis of maturity stages indicated that survey timing was appropriate for the Shumagin, Shelikof Strait, Chirikof shelf-break, and Marmot Bay surveys but may be scheduled slightly earlier for future Sanak Trough and Morzhovoi Bay surveys.

The pollock abundance estimate this year for the southeastern Bering Sea survey near Bogoslof Island was similar to the 2006 estimate. Adult pollock were concentrated in two main areas as in recent years' surveys: northeast of Umnak Island, and north of Samalga Pass between the Islands of Four Mountains and Umnak Island (Fig. 3). In 2007 most pollock were in the Samalga region, whereas in 2006 most were in the Umnak region. The pollock size composition ranged between about 39 cm and 72 cm FL in both areas and was characterized by a dominant mode at about 50 cm FL, with a

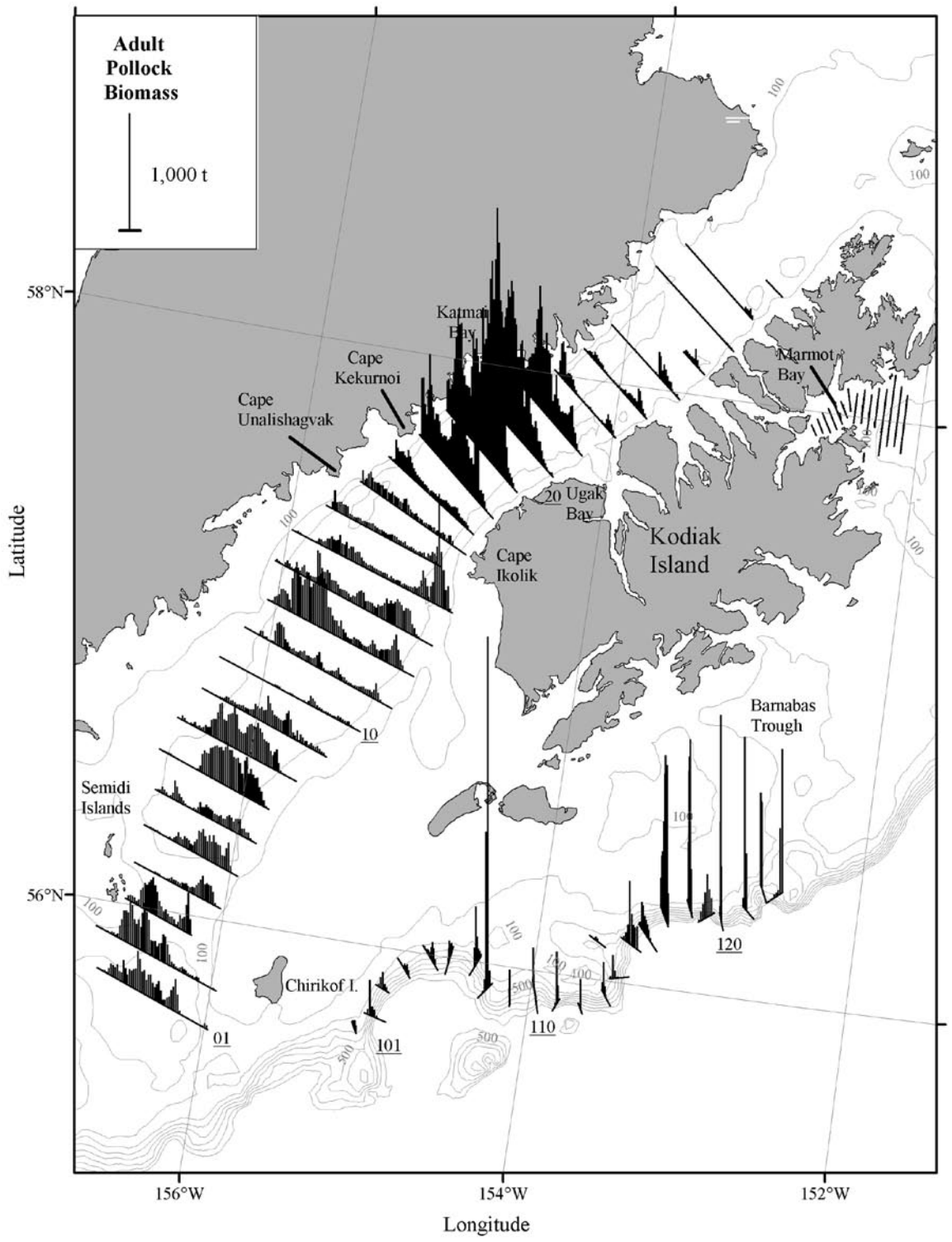


Figure 2. Estimated walleye pollock biomass in metric tons (t) (vertical lines) along transects from the 11-29 March 2007 echo integration-trawl survey of the Shelikof Strait area, along the Gulf of Alaska shelf-break near Chirikof Island, and Marmot Bay.

weaker mode at about 61 cm FL. The majority of the dominant-mode pollock were most likely from the 7-year-old, 2000 year class. Preliminary analysis of maturity stages indicated that in 2007 the majority of females were prespawning in both Samalga and Umnak, in contrast to 2006 when most Samalga females were prespawning, but most Umnak females were postspawning.

By Chris Wilson

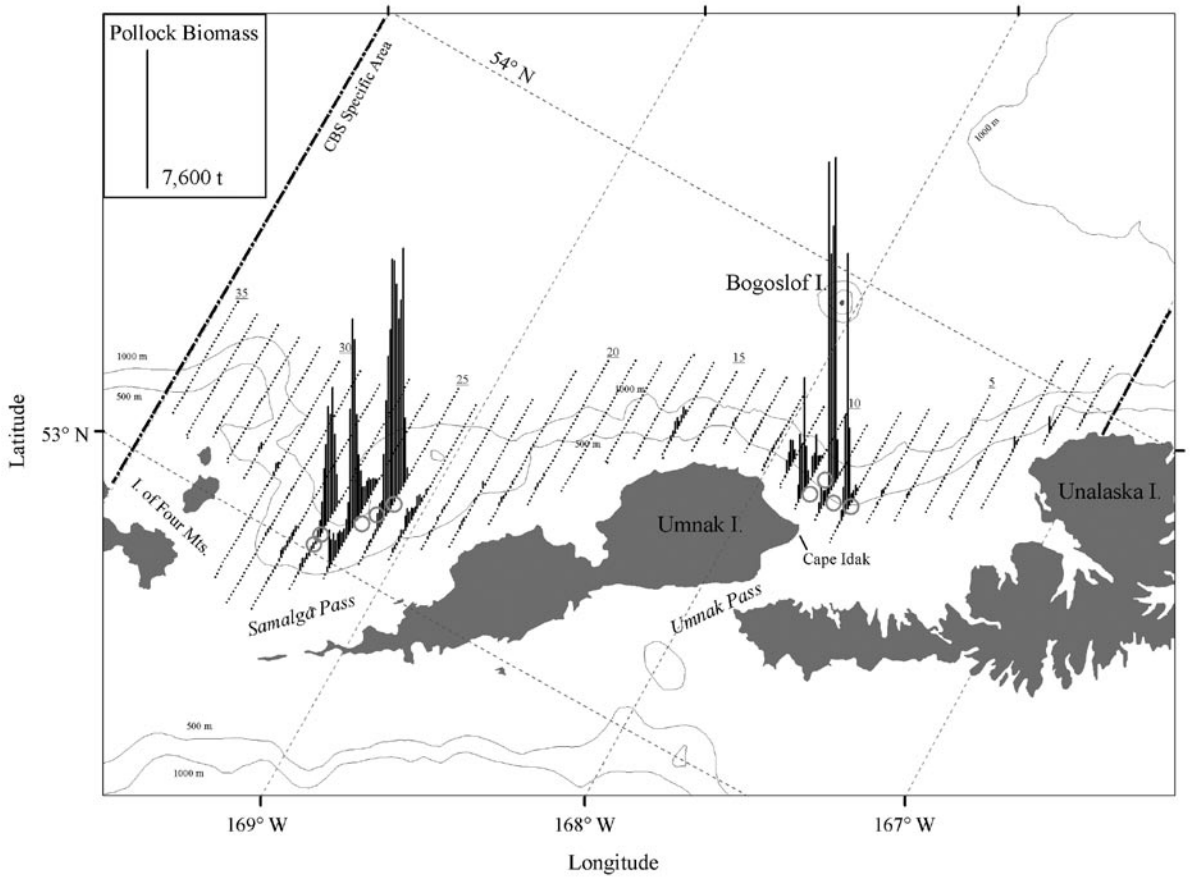


Figure 3. Estimated walleye pollock biomass in metric tons (t) (vertical lines) and trawl hauls (circles) along transects from the 1-10 March 2007 echo integration-trawl survey of the Bogoslof Island area. The Central Bering Sea Convention area is indicated by a dash-dotted line.

KODIAK LABORATORY: SHELLFISH ASSESSMENT

Warming Climate Reorganizes Bering Sea Biogeography

Sea ice is a dominant factor in the year-round bottom water conditions on the Bering Sea shelf. This layer of winter ice creates a pool of cold (< 2° C) bottom water that persists through the summer. Loss of sea ice from the Bering Sea therefore implies a loss of the cold water pool with a greater warming of bottom temperatures and subsequent potential for concomitant ecological reorganization of marine organisms. Program scientist Mike Litzow and collaborator Franz Mueter (Sigma-Plus Consulting), with support from the North Pacific Climate Regimes and Ecosystem Productivity (NPCREP) study, analyzed the RACE Division Bering Sea bottom trawl survey time series (1982-2006) to test for northward shifts in the location of the cold pool and the centers of distribution of both fish and crustacean populations in the southeast Bering Sea. Their analysis found that the average bottom temperatures measured during the survey period, when adjusted for seasonal differences in sampling, warmed approximately 0.9°C since 1982 (from 2.1° to 3.0°C) as defined by the best linear fit to annual mean values. At the same time, the southern edge of the cold pool (defined by the 2°C isotherm) has shifted approximately 230 km northwards, from an average southernmost point of about lat. 56.0°N in 1982-86 to lat. 58.1°N in 2002-06 (Fig. 1).

As would be expected, shifts in distribution of marine organisms would be a conspicuous biological response to these changes in ocean conditions, and their analysis showed the average center of abundance for 45 of the most common fish and crustacean taxa sampled on the trawl survey has migrated 31 ± 60 (SD) km northwards since 1982. Considerable variability exists among taxa in the degree of distribution change, and we could not explain this variability in terms of commercial fishing

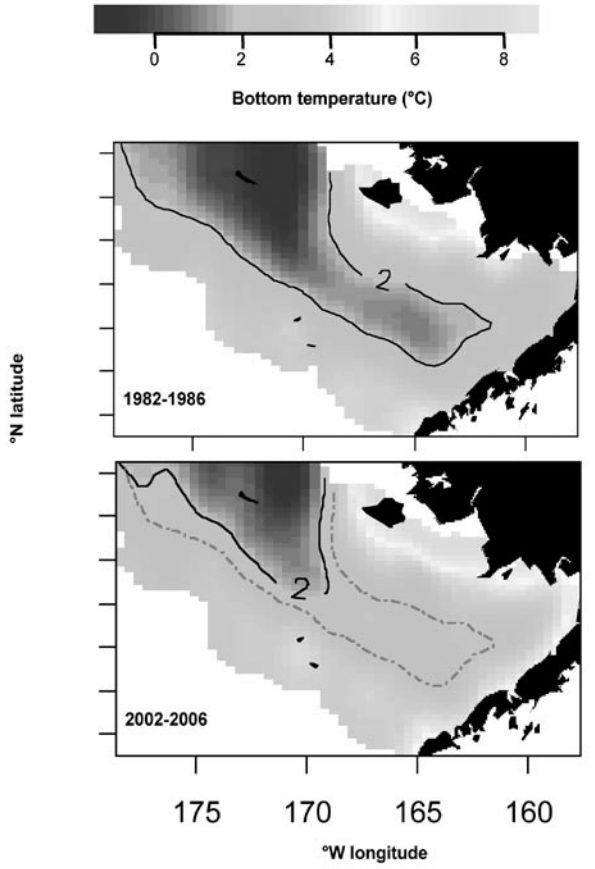


Figure 1. Average summer location of the Bering Sea cold pool (temperature < 2° C) during the first 5 years (1982-86) and most recent 5 years (2002-06) of the RACE Division eastern Bering Sea bottom trawl survey time series.

effects, trophic level, foraging habitat, or life history traits. Direct temperature effects explain a large degree of observed community-wide northward shifts in abundance (Fig. 2A), but residual variability in centers of distribution not explained by bottom temperature shows a coherent temporal trend towards accelerating distribution change in recent years (Fig. 2B).

This residual variability was not explained by the other climate parameters that we examined (e.g., ice cover, sea level pressure, wind mixing, alongshore wind stress). One of the great challenges in forecasting ecological responses to climate forcing is the potential for emergent ecological effects that magnify the effect of climate perturbation. Franz and Mike speculate that the trend in residual variability in community-wide distribution change (Fig. 2B) might indicate an emerging effect whereby the sum of community-wide distribution change exceeds that expected from direct climate effects. Understanding the causes of this trend in residual variability and variability among taxa in distributional responses to warming are two important research challenges for understanding the response of the Bering Sea ecosystem to future warming.

Finally, the loss of sea ice and warming of bottom waters has immediate management implications. Commercial catches of snow crab (*Chionoecetes opilio*), far and away the most important commercial species in the Bering Sea arctic community, are strongly positively correlated with the extent of sea ice (Fig. 3A).

Recession of sea ice in recent decades also has implications for the sum total of commercial Bering Sea fisheries. The average trophic level of all Bering

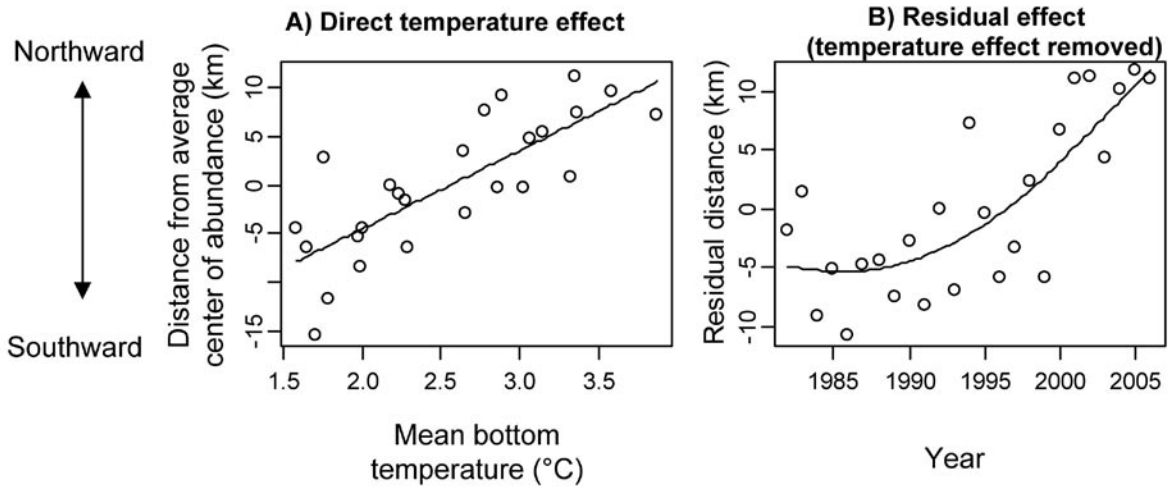


Figure 2. Warming climate and community-wide distribution shifts in the Bering Sea, 1982-2006. (A) Direct temperature effects on community-wide centers of abundance. Each dot represents peak center of abundance averaged across 45 fish and crustacean taxa for one survey year. Distance values on y-axis reflect difference from mean latitude of community-wide centers of abundance averaged across entire time series. (B) Trend in residual community-wide centers of abundance after direct temperature effects from (A) have been removed.

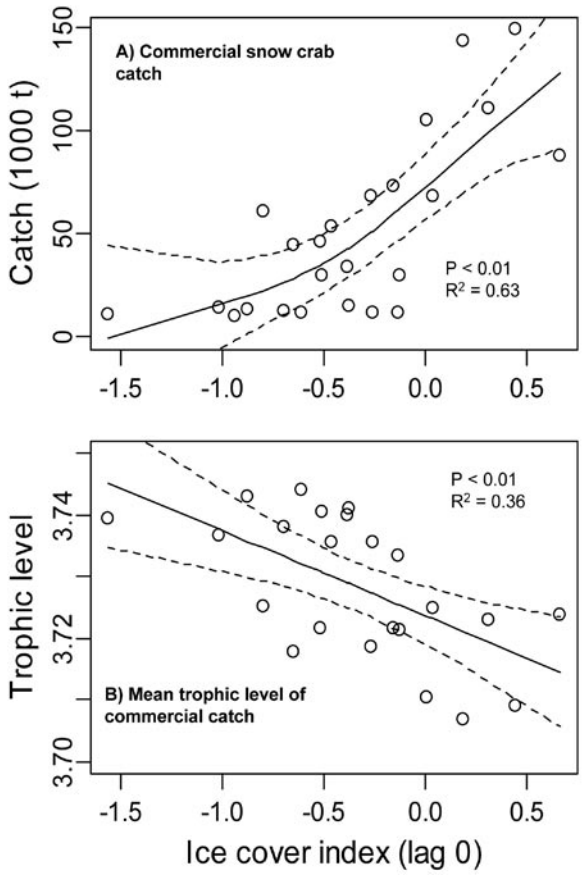


Figure 3. Immediate management implications of receding Bering Sea sea ice. (A) Correlation between ice extent and commercial snow crab catch, 1982-2005. (B) Correlation between ice extent and mean trophic level of entire Bering Sea commercial catch, 1982-2004. Ice cover index in both panels has been smoothed with 3-year running mean. Solid line indicates smoothed non-parametric regression, dotted lines indicate 95% confidence intervals around best-fit regression.

Sea fisheries is negatively correlated with ice extent (Fig. 3B), indicating a reorganization in fisheries as ice has retreated, where crab catches have declined and groundfish catches have stayed constant or increased.

By Mike Litzow

NEWPORT LABORATORY FISHERIES BEHAVIORAL ECOLOGY PROGRAM

Thermal Influences on Walleye Pollock Behavior and the Bering Sea Food Web

Temperature represents the most pervasive aspect of the environment affecting ectotherms and varies markedly on a variety of spatial and temporal scales. However, our understanding of the impact of temperature on marine food webs remains insufficient to address the consequences of long-term climate variability. This is in part because knowledge of the behavioral responses of fishes to temperature variation lags well behind our understanding of physiological responses. This has occurred despite the fact that behavior represents the link that allows (or prevents) physiological processes from scaling up to population and ecosystem-level responses.

Research at the Fisheries Behavioral Ecology Program (FBEP) continues to address the responses of Alaskan resource species to temperature variation and how these relate to food-web energetics and habitat quality. The approaches to these studies range from detailed observations of activity patterns of fish in small groups, to statistical analysis of the Bering Sea food web.

In one experiment, Thomas Hurst examined the swimming characteristics (routine swim speed, path sinuosity, and group cohesion) of juvenile walleye pollock in large arenas at temperatures between 2° and 9°C. Routine swim speed and maximum swim speeds (measured in a recirculating flume) had contrasting responses to temperature, demonstrating a behavioral rather than physiological regulation of activity level. Contrary to most assumptions, routine swim speed was higher at the low temperatures, whereas maximum swim speed displayed the expected increase with temperature. Hence, at low temperatures, walleye pollock use a much larger fraction of their swimming capacity in routine activity, leaving a smaller scope for activity (Fig. 1). Furthermore, these observations have important implications for bioenergetic analyses of growth and production of pollock. Specifically, they suggest that current models may be markedly underestimating the metabolic expenses and energetic

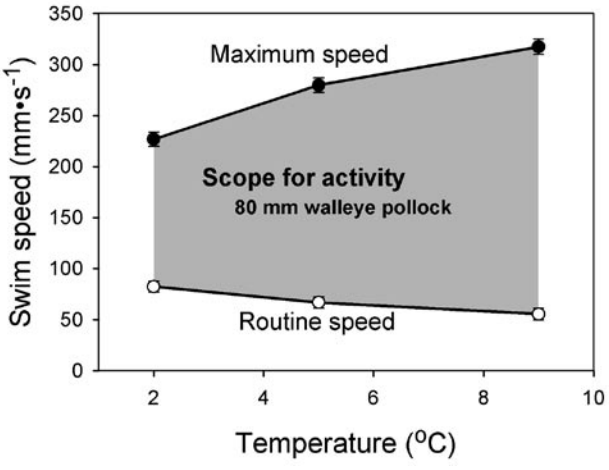


Figure 1. Scope for activity of an 80 mm juvenile walleye pollock as a function of temperature. Scope for activity is expressed as the difference between maximum swimming speed measured in recirculating flume and routine swim speed measured in 2.9 m diameter arenas.

Figure 2. Representation of computerized analysis of thermal effects on walleye pollock predation vulnerability. Figure shows the digitized paths of six pollock prey (avg. 78.7 mm TL) and one pollock predator (232 mm TL) in a 2.9-m diameter area over 14 seconds (420 frames) at initiation of attack. The digitized fish path output is overlaid on a still-frame from overhead video.

requirements for growth of juvenile walleye pollock and species with similar thermal responses at low temperatures.

Another result of that study was that juvenile walleye pollock schooled more tightly at low temperatures than they did at higher temperatures, potentially serving to reduce predator encounters or increase survival following an encounter. Predator encounter rates reduce as the inter-fish distances and areal extent of the group decline. The reduction of distances between fish may also enhance the effectiveness of group responses when faced with an attack. Following up on the latter possibility, Hurst is working with FBEP technician Rich Titgen and University of Washington colleague Danny Grunbaum on analyzing the responsiveness of juvenile pollock to attacks by larger pollock.

They have been adapting a computerized fish tracking system developed by Grunbaum for the difficulties of working with small targets (prey) in large experimental arenas. After stereotyped predator attacks are isolated on the video, the software identifies and tracks the position of each prey fish through the encounter with the predator (Fig. 2). The responsiveness of the prey group is described by metrics such as the distance at which their escape behavior is elicited and the time required for the prey to reform a cohesive group.

From a different perspective, the thermal forcing of marine food webs is being examined through an analysis of the AFSC food habits database with REFM colleague Troy Buckley. The researchers are looking at relationships between (spatial and interannual) thermal variation observed in the summer groundfish survey and the diet composition of Pacific cod. Of particular interest is the predatory effect of cod on walleye pollock. Preliminary results indicate that temperature has a significant impact on the size classes of pollock consumed by cod in the southeast Bering Sea. At low temperatures (especially below 0.5°C), cod predation is focused almost exclusively on pollock less than 150 mm standard length (SL). At higher temperatures (over 3.5°C), over 15% of pollock consumed by cod were larger than 450 mm SL (representing 47% of pollock biomass). Alternative explanations for the observed shift in vulnerability of pollock to predatory cod are changes in encounter rates associated with distributional overlap or changes in relative physiological performance between predator and prey.

By approaching the question of thermal effects on food web dynamics from multiple perspectives, and combining laboratory and field studies, the research at the FBEP has the potential to improve empirically-based assessments of trophic control of managed species as well as the mechanistic understanding of these responses.

By Thomas Hurst

RESOURCE ECOLOGY & FISHERIES MANAGEMENT (REFM) DIVISION

RESOURCE ECOLOGY AND ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

Laboratory analysis was performed on 2,470 groundfish stomachs from the eastern Bering Sea and on 386 groundfish stomachs from the Gulf of Alaska. A total of 2,265 Bering Sea samples and 69 Gulf of Alaska samples were collected by fisheries observers; 9,666 records were added to the groundfish food habits database.

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

Multispecies and Ecosystem Modeling

Dr. Ivonne Ortiz successfully defended her University of Washington doctoral dissertation entitled "Ecosystem Dynamics of the Aleutian Islands." This work combines substantial historical information of human interactions with the Aleutian Islands ecosystem with ecosystem-level and fine-scale modeling of ecosystem processes in the fisheries management region, building towards the development of a fisheries ecosystem plan

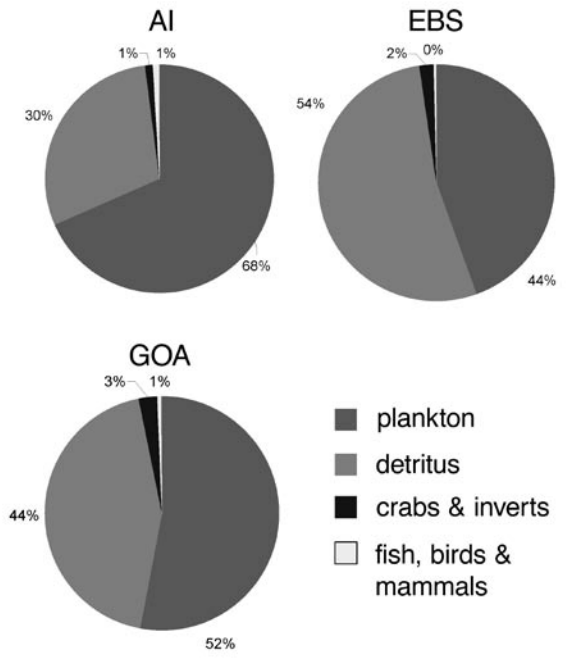


Figure 1. Relative total consumption of major prey types in three Alaskan marine ecosystems. From left to right: Aleutian Islands (AI), eastern Bering Sea (EBS), and Gulf of Alaska (GOA).

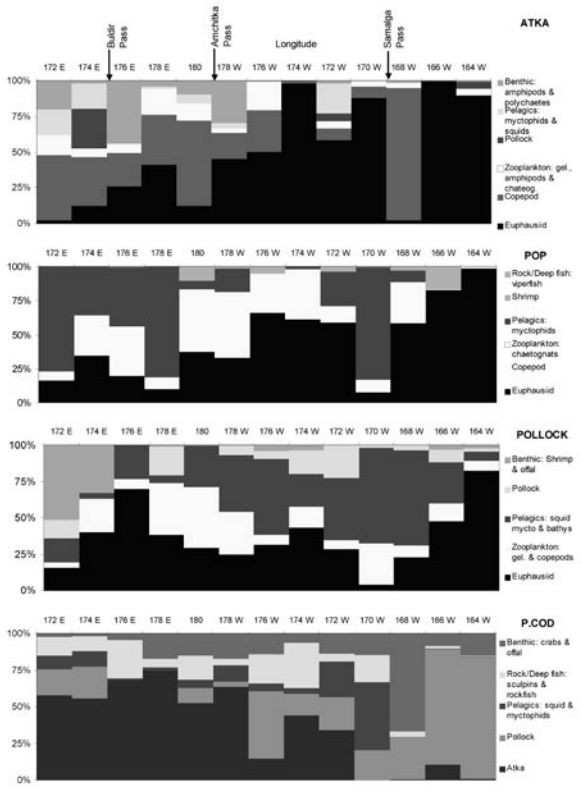


Figure 2. Important prey of four major groundfish species in the Aleutian Islands, shown by 2° longitude blocks across the island chain. Predators from top to bottom: Atka mackerel, Pacific ocean perch, walleye pollock, and Pacific cod.

(FEP). The work completes a "three region" comparative picture of the food webs of the Bering Sea, Gulf of Alaska, and Aleutian Islands ecosystems which has been developed by the Resource Ecology & Ecosystem Modeling (REEM) Program over the last several years. The completion of this work will allow the comparison of processes between ecosystems (Fig. 1) as well as allowing detailed examination of processes occurring within the Aleutian Islands archipelago (Fig. 2).

By Ivonne Ortiz and Kerim Aydin

Ecosystem Assessment

REEM scientists participated in a multi-agency collaboration to compile, edit, and present a working draft Aleutian Islands Fishery Ecosystem Plan (FEP) (*http://www.fakr.noaa.gov/npfmc/current_issues/ecosystem/AIEFP307.pdf*) to the North Pacific Fishery Management Council (NPFMC) at its February and March/April 2007 meetings. The full Aleutian Islands FEP team includes participants from the AFSC's Status of Stocks & Multispecies Assessment (SSMA) Program, the NMFS Alaska Regional Office, NOAA's Pacific Marine Environmental Lab, the Alaska Department of Fish and Game (ADF&G), the U.S. Fish and Wildlife Service, the North Pacific Research Board (NPRB), and NPFMC staff. In addition, the dissertation research by Dr. Ivonne Ortiz on spatial food webs in the Aleutian Islands played a central role in FEP development.

The draft Aleutian Islands FEP describes the ecosystem in terms of historical, physical, biological, socio-economic, and management relationships, and uses the description of these relationships to identify key interactions in the ecosystem. Examples include the interaction of water temperature with biological processes, the interaction of fisheries with predator-prey relationships, and the interaction of international shipping with local ecology. For each interaction, a set of ecosystem indicators was identified to evaluate whether the interaction was changing relative to our current knowledge of the ecosystem. Some ecosystem indicators already exist for the Aleutian Islands, but others identified by the team still need to be developed. The FEP team evaluated the relative probability of each interaction occurring and what type of ecological and economic impacts might arise from each interaction within a qualitative risk assessment framework.

The results of this exercise are currently being refined by the FEP team so that interactions identified as both high probability and high risk can be brought to the attention of the Council to provide context for their fishery management decision making process. The team envisions that ecosystem indicators developed for the Aleutian Islands might be incorporated within the Ecosystem Considerations section of the Stock Assessment and Fishery Evaluation (SAFE) report to be annually reviewed by the Council. At present, the team is working to provide advice to the Council on how to incorporate the ecosystem level advice compiled in the FEP within fishery management in the Aleutian Islands. The Council is scheduled to review a complete document at its June 2007 meeting.

By Sarah Gaichas

Ecosystem Indicators

Hydrographic structure is a dynamic feature that profoundly affects patterns in distributions, productivity, and interactions among species over the eastern Bering Sea (EBS) continental shelf. The depth-temperature profile during the spring-summer warming season over the EBS shelf represents an integration of mixing and stratifying forces. Depth-temperature profile data have been collected annually over the EBS shelf since 1982 during the EBS bottom trawl survey conducted by the AFSC's RACE Division. From each depth-temperature profile we are calculating statistics that describe potentially important habitat characteristics of the hydrographic structure. These characteristics are generally related to nominal temperatures, strength of stratification, and layering of the water column, which in turn help define types of water masses, fronts between them, and pelagic habitat. We are investigating possible relationships between species distributions and interactions with respect to these water column characteristics. In addition, we felt that some of these descriptive statistics would lend themselves to the creation of annual indices of water conditions integrated over the EBS shelf (Fig. 3), with the caveat that survey timing differs somewhat among years.

By Troy Buckley, Angie Greig, and Jennifer Boldt

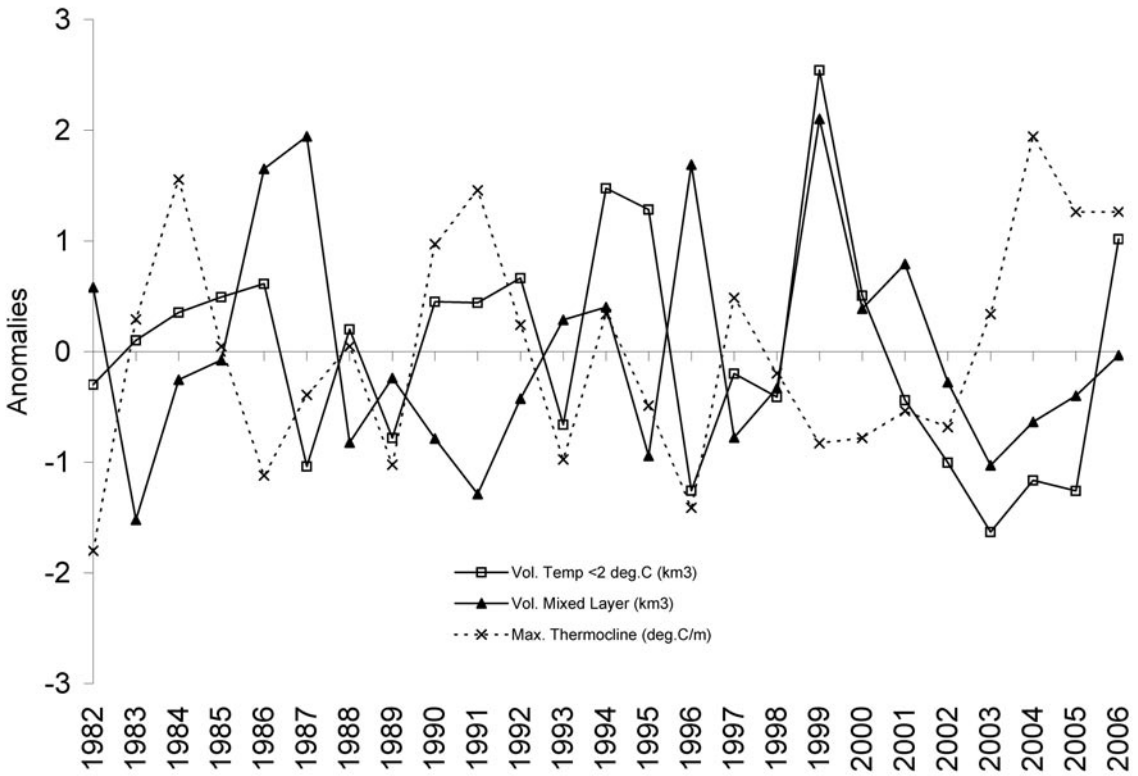


Figure 3. Examples of the types of indices that were calculated from water depth-temperature profiles over the eastern Bering Sea continental shelf (volume of water < 2°C, volume of the mixed surface layer, and the average of the maximum thermocline at each profile). Values are shown relative to their mean across all years.

Seabird Interactions

Dr. Ann Edwards, National Research Council postdoc with the AFSC, completed field work on Laysan albatross at Midway Atoll in the Hawaiian Leeward Islands in coordination with the U.S. Fish and Wildlife Service (USFWS) (Fig. 4). The goals of the research were to sample feathers (for delta-15N analysis as an index of diet) in such a way as to link foraging patterns (inter-annual and intra-annual variation) and diet (specifically a "fisheries-associated" diet indicated by elevated delta-15N values) primarily to reproductive success. Secondary goals were to link foraging and diet to age, breeding status, gender, and relative influence on reproductive success of a mate's diet. Edwards sampled birds from USFWS reproductive plots (150 albatross), from pre-breeders (30 birds), and from older breeders outside of the reproductive plots (43 birds). Based on work completed for her Ph.D. research at the University of Washington, molting patterns and feather growth rates and genetic sequence are known for Laysan albatross. By taking small feather clips from several different feathers and different locations on a single feather and conducting stable isotope analysis, the trophic level that birds were feeding at can be determined up to several years in the past. Samples are currently being analyzed.

By Shannon Fitzgerald

Figure 4. AFSC researcher Dr. Ann Edwards cuts a 1-mg piece of primary feather for stable isotope sampling from an incubating Laysan albatross breeding on Midway Atoll.

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Halibut Sport Fishing Survey Update

To assess the impacts of potential regulatory changes on sport angler behavior, it is necessary to have estimates of the baseline demand for halibut fishing trips and an understanding of the factors that affect it. To this end, Drs. Dan Lew and Doug Larson (University of California, Davis) developed a survey to gather data for estimating demand and understanding angler preferences for Alaska saltwater sport fishing. The survey collects information about an angler's 2006 Alaska sport fishing activities (primarily saltwater fishing activities) and preferences that will be used to estimate two types of economic models.

The first model is a recreation demand model that will explain decisions about the sites chosen and the number and types of saltwater sport fishing trips demanded by Alaska resident and nonresident anglers. This model will utilize information about angler behavior collected in the survey including the sites fished, number of trips taken, types of fishing trips taken (charter boat, private boat, or shore fishing), catch, and costs.

The second model will estimate preferences for saltwater fishing trips using responses to survey questions that ask individuals to choose between several hypothetical fishing trips that vary in key characteristics (e.g., species targeted, catch, limits, and cost). Responses are analyzed within a statistical framework that models the choice between those available in each question. In this framework, the effect on preferences and behavior of changes to policy variables such as daily bag limits can be assessed. Combining the information from this stated preference model with the recreation demand model to yield improved estimates will also be explored.

The models will be estimated for each of three angler groups: Southeast Alaska resident anglers, other Alaska resident anglers, and nonresident anglers. Southeast Alaska anglers will be treated as a distinct group due to the differences in saltwater sport fishing opportunities in Southeast Alaska relative to the rest of the state.

The survey is currently being fielded. At the end of January, the questionnaire was mailed to a stratified sample of 4,000 Alaska resident and nonresident anglers who were licensed to sport fish during 2006. To maximize response rates for this voluntary

survey, several follow-up mailings were and are being conducted, in addition to a telephone contact. The data collection is expected to conclude by May, with data analysis following shortly thereafter.

By Dan Lew

Fishing Revenue, Productivity, and Product Choice in the Alaskan Pollock Fishery

Dr. Ronald Felthoven at the AFSC has been working with Professor Catherine Morrison Paul and Marcelo Torres at the University of California, Davis on a paper to examine the way in which economic performance in the pollock catcher-processor fleet has changed over time and in response to the American Fisheries Act (AFA). In this paper we use a flexible revenue function that allows consideration of interactions among all its arguments, including inputs (crew, vessel characteristics, and fishing methods) and environmental factors (weather), to evaluate production and economic performance in the Bering Sea and Aleutian Islands pollock fishery. This rich framework results in a wide range of estimates reflecting the contributions of market, technological, regulatory, and environmental factors to revenue, productivity, product supply, and input shadow values.

We find significant supply responsiveness to own- and cross-product prices, as well as to inputs (such as crew numbers and tows) and external factors. In particular, our estimates show that increasing days fished and towing duration during each season, and to a lesser extent the number of tows, have augmented fishing revenues by contributing to the production of deep-skin (higher quality) fillets and roe. In reverse, these estimates imply that increasing prices of roe and deep-skin fillets have significantly increased the value of inputs used in fishing, especially tow numbers (for roe) and duration, but also crew and vessel size. These patterns are consistent with the industry perception that the change to a quota-based fishery has reduced the pace of fishing and processing effort, permitting greater flexibility and facilitating lucrative product choice and quality changes.

We also find a significant residual upward trend in revenues that indicates increasing economic productivity, and is substantially greater post-AFA. This productivity growth is strongest over the whole period for both types of fillets but increasing the most rapidly (and to the highest level in terms of its marginal contribution to revenue) for roe. It also has contributed to higher shadow values of inputs, including especially tows and crew. This paper will be submitted for publication in a peer-reviewed journal this spring.

By Ron Felthoven

AFSC Social Scientists Examine the Connections between Environment and Demography

Drs. Jennifer Sepez and Michael Dalton of the Economics and Social Sciences Research (ESSR) Program both presented research in environment and demography at the Population Association of America (PAA) meetings in New York, 29-31 March 2007.

Dr. Sepez presented "Recent and Historic Population Trends in the Bering Sea and Aleutian Islands: Hubs and Spokes, Booms and Busts," along with coauthor Amanda Poole of the University of Washington. The paper reports on research they undertook last year looking at possible connections between demography and climate change in the Bering Sea/Aleutian Islands (BSAI). Human populations in that area have been increasing since the 1920s, a trend which could accelerate or reverse under different global climate change scenarios. In larger hub communities, a net in-migration has been generated by foreign-born immigrants drawn as labor to the seafood processing industry. In many small villages, net out-migration for education and economic opportunity is countered by a high birth rate among Native Alaskan populations. Most communities that have experienced negative population growth in the last 15 years are those closely linked to the salmon fishery which has suffered economically with the growth of global production and trade of farmed fish.

This research is part of a larger project which will attempt to construct models that predict potential demographic impacts of ecosystem changes stemming from global climate change. An early version of the paper was published in the 2006 SAFE report. An updated version of the paper can be found on the web at *http://paa2007.princeton.edu/download.aspx?submissionId=71584*.

Dr. Dalton presented some of his recent work on a global economic growth model in a session called Environmental Consequences of Population Growth/Decline. Further work on the Alaska and U.S. components of the global model is described

in the section on Alaska Fisheries and Global Trade. The presentation at PAA, "Demographic Change and Future Carbon Emissions in China and India," is based on a paper by Dalton, Leiwen Jiang of Brown University, Shonali Pachauri, and Brian O'Neill, both of the International Institute for Applied Systems Analysis (IIASA). This paper investigates whether projected changes in the demographic characteristics of Chinese and Indian households over the next century could have a substantial influence on consumption, economic growth, energy demand, and carbon dioxide emissions. The authors use new household projections for China and India that model changes in population size, urbanization, and the size and age structure of households over the next 100 years. The initial economic characteristics of different household types, including demand for consumer goods, supplies of labor, and capital, are estimated from household surveys and production data for each country. A global energy-economic growth model simulates economic growth as well as changes in consumption of various goods, direct and indirect energy demand, and carbon emissions over time. Effects of demographic change are compared under different scenarios from the Intergovernmental Panel on Climate Change (IPCC) that include technical change. Results show that explicit consideration of urbanization leads to a substantial increase in projected emissions, while aging leads to a decrease. The net effect of demographic change is to increase projected emissions from China by 45% by the end of the century, and from India, by 15-35%. The draft paper is available online at *http://paa2007.princeton.edu/download.aspx?submissionId=72123*.

By Jennifer Sepez and Mike Dalton

Estimating Economic Base Relationships for Alaska Fisheries Using Borough-level North American Industry Classification System (NAICS) Data

Virtually all regional economic impact models developed so far for analysis of U.S. fisheries are static models. With static models, it is impossible to address the timing of the impacts, which needs to be considered in formulating fishery management policies. An alternative model that avoids these weaknesses is a dynamic economic base model, which is often implemented with a vector autoregressive error correction (VECM) model.

The VECM model is able to estimate the time and magnitudes of regional economic impacts in response to shocks to seafood industries as well as the long-run relationships between basic industries (including seafood industry) and nonbasic (supporting) industries. Using monthly employment data at regional levels from 1990 to 2000, Dr. Chang Seung, ESSR Program, developed VECM models for two fishery-dependent regions in Alaska – the Southwest and Gulf Coast regions. In the model, the dynamic impacts of seafood industry on the economies of the two regions were investigated. Recently, the Alaska Department of Labor and Workforce Development completed a project for NMFS in which borough–level monthly employment data was prepared using the North American Industry Classification System (NAICS) system. This data will allow us to conduct research in which the impacts of seafood industry can be examined for each of the fishery-dependent boroughs and census areas. Using this NAICS data, Dr. Seung will develop dynamic economic base models for fishery-dependent boroughs and census areas. Depending on whether a funding proposal is successful, the project may be jointly conducted with Professor Sung Ahn at Washington State University.

By Chang Seung

BSAI Crab Economic Data Reporting Data: Protocols for Confidentiality and Data Quality

Based on public testimony and a recommendation from the Advisory Panel (AP) at the December 2006 meeting, the NPFMC passed a motion directing staff to develop protocols concerning data collected under the BSAI crab rationalization Economic Data Reporting (EDR) Program. The protocols apply to two general areas: 1) maintaining data confidentiality and 2) assessing the quality of the data to ensure accuracy.

ESSR Program scientists prepared a discussion paper to outline the legal, regulatory, and administrative standards that apply to confidentiality and data quality, and remaining issues to be resolved in regard to crab EDR data. The paper sets forth the process that AFSC staff, in collaboration with Council and NMFS Alaska Region staff, will undertake to develop both sets of protocols to ensure that industry and Council concerns regarding the crab EDR program are addressed. The paper was presented at the March/April Council meeting and re-

ceived the endorsement of the AP and Council (time limitations did not allow the Council's Scientific and Statistical Committee to receive a presentation of the paper). The protocols will be developed with public, industry, and scientific peer input, with workshops to be held during summer 2007. Protocols are expected to be in place concurrent with completion of 2006 EDR data collection and verification (4th quarter, FY07), which will provide the second year of economic and social data collected post-rationalization.

By Brian Garber-Yonts

Alaska Fisheries and Global Trade

This project is aimed at integrating international trade data that are associated with Alaska fisheries (see *AFSC Quarterly Report*, October-December 2006) into a global economic growth model that represents international trade, which has a regional component for Alaska. Recent work on the global model is described above in the section on environment and demography by Sepez and Dalton. In addition, Dr. Chang Seung of the ESSR Program prepared benchmark economic data for Alaska and the United States that will be used in the global model. Dr. Shonali Pachauri of the International Institute for Applied Systems Analysis (IIASA) prepared supplemental information, obtained from the International Energy Agency to complete the U.S. benchmark. Dr. Leiwen Jiang of Brown University is preparing benchmark data for the rest of the world from the Global Trade Analysis Project (GTAP). While exports of certain seafood products from Alaska are available in the U.S. Merchandise Trade Statistics, a consistent set of trade flows (including re-exports) among other countries (e.g., China, Japan, Korea) for seafood products that are not otherwise available from the GTAP will be estimated from the U.N. Merchandise Trade Statistics, and Food and Agriculture Organization data on fish production and trade, using a new procedure developed by Dalton.

By Mike Dalton

Developing a Computable General Equilibrium Model for Alaska Fisheries

Fixed-price models such as input-output (IO) and social accounting matrix (SAM) models are often used for analysis of fisheries. However, these models have several important limitations. In these models, prices are assumed to be fixed, and no substitution is allowed between factors in production or commodities in consumption. As a result, in cases where the fixed-price assumption may not be realistic, these models tend to overestimate impacts. Computable General Equilibrium (CGE) models overcome these limitations. In CGE models, prices are allowed to vary, triggering substitution effects in production and consumption. The CGE model therefore enables analysts to more easily examine the economic welfare implications of a policy change. Furthermore, the CGE approach is generally more appropriate than other regional economic models for analyzing the impacts of a change in productive capacity of resource-based industries. Therefore, Drs. Chang Seung (ESSR Program) and Edward Waters (contractor) will build the first Alaska fisheries CGE model, and use the model to estimate the distribution and magnitude of economic impacts associated with harvesting, processing and support activities related to Alaska fisheries. The investigators will use IMPLAN, a commercially available set of data for conducting regional economic analyses, and other available data. Once developed, the CGE model will be used to estimate economic impacts of selected, relevant policy issues affecting commercial fishing and related activities in Alaska.

By Chang Seung

Estimating Heterogeneous Capacity and Capacity Utilization in a Multispecies Fishery

ESSR scientist Dr. Ronald Felthoven has been working with Professors Kurt Schnier and Bill Horrace at the University of Rhode Island and Syracuse University, respectively, to develop a stochastic production frontier model that accommodates heterogeneous fishing production technologies within a fishery and internally partitions these different technologies into identifiable groups. One of the goals of this research is to investigate the impact of this more flexible model on measures of fleet capacity and capacity utilization in a multispecies fishery. In our research we propose a new fleet capacity estimate that incorporates complete information on the stochastic differences between each vessel-specific technical efficiency distribution. Results indicate that ignoring heterogeneity in production technologies within a multi-species fishery, as well as the complete distribution of a vessel's

technical efficiency score, may yield erroneous fleet-wide production profiles and estimates of capacity. Furthermore, our new estimate of capacity enables out-of-sample production predictions predicated on either homogeneity or heterogeneity modeling which may be utilized to inform policy makers. A paper on the subject will be submitted for publication in a peer-reviewed journal this spring.

By Ron Felthoven

BSAI Crab EDR Validation Audit

In collaboration with Pacific States Marine Fisheries Commission, ESSR Program scientists have overseen a validation review of BSAI Crab EDR data by the accounting firm Aldrich, Kilbride and Tatone, LLC (AKT). Principal objectives of the validation exercise are to assess and quantify the measurement error associated with the EDR instruments and provide an incentive to maintain accuracy and rigor in reporting cost and earnings information. The validation review includes both random audits, based on a statistical sample of the EDR population, and nonrandom audits of EDRs identified on the basis of missing variables or outliers in reported information. As of March 2007, a portion of the audits remained incomplete due to nonresponse from submitters, who were referred to NMFS Alaska Region Enforcement. AKT selected vessels or processors for audit based upon a statistical sample; for each vessel or processor selected for audit, detailed support was requested and examined for each year in which the selected vessel or processor submitted an EDR. Variables for audit were selected from those that could be validated by documented support. For each data variable requested, AKT critically evaluated the support provided against third-party support, such as invoices or fish tickets; internally-generated information, such as crew settlement sheets, general ledger details, detailed internal reports, or financial statements; and estimates made, including the reasonableness of assumptions. AKT also noted when no support was available to evaluate the information. Preliminary results of the audit indicated that the information submitted in EDRs was generally well-supported by documentation and records. However, despite the specific definitions included in the EDRs, there is still variability in how information is reported based upon the ability to break down information in the manner requested in EDR forms. In addition, there is significant variability in the quality of supporting documentation to information submitted in the EDRs. A final revision of the audit report will be completed in early third quarter FY07 and used in development of data quality protocols for the crab EDR data and revisions to the EDR forms.

By Brian Garber-Yonts

Evaluating the Cost and Effectiveness of Fixed and Rolling Bycatch Closures in the Bering Sea

Bycatch is repeatedly noted as a primary problem of fisheries management and as the foremost negative impact of commercial fishing. In the Bering Sea pollock fishery, salmon bycatch reduction measures have included gear modifications but have principally consisted of area closures. Bycatch levels of chum and Chinook salmon have risen substantially since the beginning of the decade and significant areas of the pollock fishery have been closed at some points between 2002 and 2006. These closures have consisted of both large long-term Salmon Savings Area closures and short-term voluntary rolling hotspot (VRHS) closures.

In February, Sea State Inc., the company that helps the pollock fleet share information about salmon bycatch, provided the ESSR Program with spatial information on the VRHS closures that have been in place since 2001. This information is fundamental to being able to analyze how fishers respond to bycatch. It also allows us to properly identify bycatch hotspots, recognizing that the areas with the highest bycatch have been temporarily closed to fishing through the VRHS system. In total, there have been more than 220 closures in an area that spans most of the pollock fishery. In March a bycatch workshop was held to present current research to the NPFMC SSC. At this workshop we outlined a number of issues of ongoing research and our methods for estimating the costs and benefits of spatial closures. We are working with AFSC scientist Dr. James Ianelli (see below) and Diana Stram of Council staff to assess potential future fixed closures and other methods of reducing bycatch.

One important insight into the design of partial-season area closures is that it is the relative difference in bycatch rather than the absolute level that is most important. If all areas have bycatch at a given point in the season, closing part of the fishing grounds will have little impact on bycatch levels. Closing a high bycatch area at a time in the season with lower overall bycatch but with more heterogeneity in by-

catch levels is more likely to lower the amount of salmon caught in the fishery.

By Alan Haynie

Comprehensive Socioeconomic Data Collection for Alaskan Fisheries

In November 2006, the ESSR Program coordinated a working group to address the NPFMC's October 2006 motion to draft a comprehensive program for collecting revenue, ownership, employment, cost, and expenditure data in Alaskan fisheries. The working group was comprised of individuals representing NMFS, ADF&G, Commercial Fisheries Entry Commission, NPFMC, NOAA General Council, and Alaska Department of Commerce. Specifically, the group met to propose a core set of data that is currently unavailable yet important for answering many of the questions raised when evaluating past and future management decisions and conducting regulatory and legally-mandated analyses.

As with any working group, there were differences of opinion within the group. For this group, the differences were primarily over the level of detail that should be required in the data collection. However, all involved basically shared the same frustration over the lack of social and economic data and felt that we need to develop a comprehensive program. The working group focused on evaluating the existing data collection programs and made specific suggestions for improving information content.

It is important to note that nearly all socioeconomic surveys of Alaskan fisheries to date have been conducted (with very little success) through voluntary reporting. There has been broad industry reluctance to provide these data, typically because of fear that the data would somehow be used against submitters (e.g., to levy enforcement penalties based on profits, or to show how much or how little money a sector or fleet is making in allocation disputes), used incorrectly, or disclosed to competitors or the public. These are reasonable concerns on the part of industry, but we believe there are solutions to these concerns that can be feasibly incorporated into the data collection program to overcome them. However, we feel it is important to emphasize that voluntary economic data collection is not a viable option in Alaska. Dozens of surveys of various lengths and level of detail have been developed by NMFS and other researchers for nearly every sector, yet the information we need is still unavailable. For the most part, the only industry cooperation has been with private contractors who were working on behalf of the harvesters or processors (often bringing the accuracy of the data into question because of the underlying incentives). Only recently in the BSAI crab and the Amendment 80 rationalization programs has socioeconomic data collection been mandated, and it is only in these fisheries where we will be able to conduct truly satisfactory economic analyses. It is therefore our opinion that only with a comprehensive mandatory data collection program can we provide the accurate information required for the analyses requested by decision makers for the various Alaskan fisheries.

The working group drafted a discussion paper, providing a detailed discussion of the specific types of information that could be collected to address common management questions, along with suggestions regarding what should or could be collected. We also address approaches for collecting data, identifying data collection frames (census versus sampling) and the relevant populations and reporting entities, data confidentiality, and the linkages between economic and social analyses. The discussion paper is available on the Web at *http://www.fakr.noaa.gov/npfmc/summary_reports/datacollection407.pdf*

By Ron Felthoven

Amendment 80 Head and Gut Catcher/ Processor Sector Economic Data Collection

Beginning in 2008, the non-AFA trawl catcher/processing (CP) sector will be rationalized under a fishery cooperative program. Under the terms of the June 2006 Council motion, a mandatory socioeconomic data collection program will be implemented for the entire sector. Key elements of the Amendment 80 problem statement are the reduction of bycatch and improved utilization of groundfish. Socioeconomic data are needed to assess whether the cooperative formation addresses the goal of mitigating the costs associated with bycatch reduction, to understand the economic effects of the Amendment 80 program on vessels or entities regulated by this action, and to inform future management actions. The program will collect cost, revenue, ownership, and employment data on an annual basis. ESSR Program scientists developed draft data collection instruments and, in collaboration with NMFS Alaska Region staff, prepared regulatory text and draft Paper Reduction Act documentation to support the data collection program. Data collection for the Head and Gut fleet is expected to begin in 2009.

By Brian Garber-Yonts

Integrating Bering Sea and Gulf of Alaska Climate Data for Socioeconomic Research

ESSR Program economists and social scientists apply a variety of models to different socioeconomic problems and issues that affect Alaskan fisheries and communities. Researchers have begun to directly incorporate the effects of climate change into a number of these models, but do not have a straight-forward means for finding and evaluating climate data collected, organized, and analyzed by NOAA and other government agencies. As AFSC fisheries scientists better understand the relationship between changing climate and fish populations, we will be able to evaluate and predict the socioeconomic impacts of the changing climate.

One area where climate data will be immediately utilized is in fisher location choice models. These models incorporate observable information on the vessel characteristics, expected returns from choosing an area, and travel distance. The models can be significantly improved by augmenting them with area-specific information on ice coverage, winds, sea surface height, and potentially, primary productivity. A second area of research will be to examine spatial correlation of economic fishery productivity and fine-scaled climate data. A third area of research is to utilize the long time series of climate data that exhibit a high degree of spatial coherence, such as sea surface temperatures, into economic models of fishery dynamics.

This project will organize important Bering Sea and Gulf of Alaska climate data that would be useful for socioeconomic researchers. Some of the data are readily available on NOAA Web sites but other data must be requested directly from researchers. The project will develop a one-stop Web site with pertinent datasets, assessments of data quality, and instructions for usage.

By Alan Haynie and Mike Dalton

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

New Public Web Sites Allow Interactive Access to Fish Distribution Data

Observation is the heart of science. Fisheries researchers are keenly aware of the importance of the diligent collection and maintenance of good data sets. Two of the data sets heavily used by the Status of Stock and Multispecies Assessment (SSMA) scientists are Resource Assessment & Conservation Engineering (RACE) survey data and Fisheries Monitoring and Analysis (FMA) observer data. Each year RACE scientists go to sea to collect trawl samples of fish abundance and species composition data. Meanwhile, observers monitor commercial fishing vessels for similar data.

In order to facilitate the understanding and use of these data sets, two new Web sites have been created, in cooperation with RACE and FMA staff: RACE Groundfish Survey Data (*http://www.afsc.noaa.gov/RACE/groundfish/survey_data/default*.htm), and Observer Data (*http://www.afsc.noaa.gov/FMA/spatial_data.htm*).

Both Web sites display fish distributions on interactive maps which allow the user to query the data by year and species. In addition to the maps, the Web sites provide data sets for download. Hopefully with better access to data collected by AFSC researchers, more people will be able to appreciate these valuable data.

By Angie Greig

Salmon Bycatch Patterns in the Eastern Bering Sea Pollock Trawl Fisheries

Measures to reduce salmon bycatch have been developed for the NPFMC and incorporated in a number of amendments to the groundfish fishery management plan (FMP). These measures result in specific closed (no-fishing) areas when established bycatch limits are reached. The closure areas were designed based on analyses of groundfish observer data collected from 1990 to 1995. Recently, Chinook and chum salmon bycatch have consistently exceeded the limits which closed large areas and altered the spatial pattern of the pollock fleet. The effectiveness of this closed-area management action is limited since salmon bycatch rates are spatially variable from year to year. Center scientists are helping evaluate options for the most effective management practices. For example, recent years of spatial and temporal salmon patterns have been evaluated and presented at this year's Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK SSI) symposium held in Anchorage in February.

For the analysis, NMFS observer data were compiled to compare numbers of salmon (categorized as either Chinook or non-Chinook salmon) with pollock catch and to get salmon-specific length

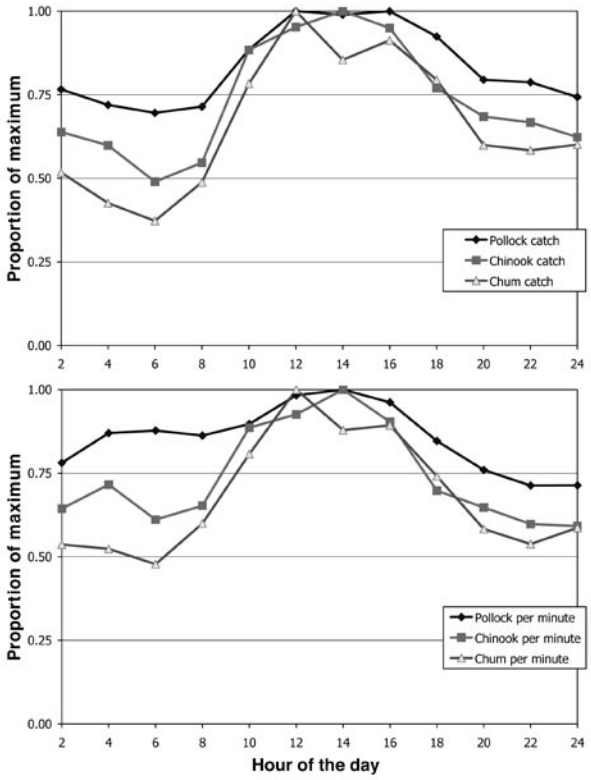


Figure 1. The patterns of pollock and salmon catch (top) and catch per minute (bottom) relative to their daily maxima based on NMFS observer data (1990-2006).

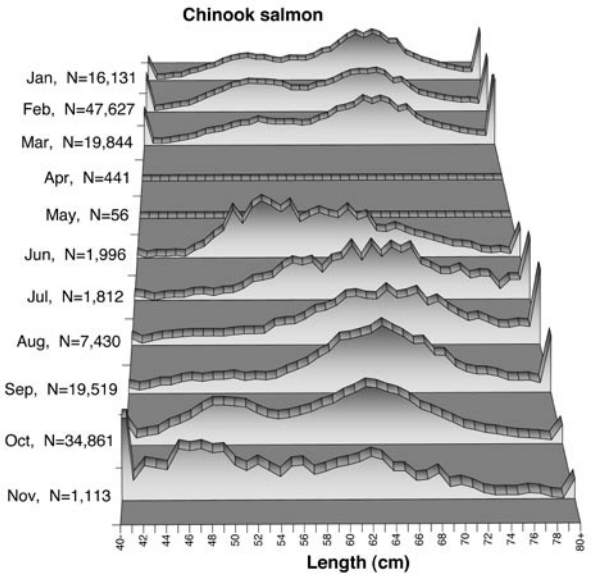


Figure 2. Chinook salmon proportions at length by month as taken in the pollock fishery, 1998-2006 combined. Month and sample sizes are shown in the left axis labels.

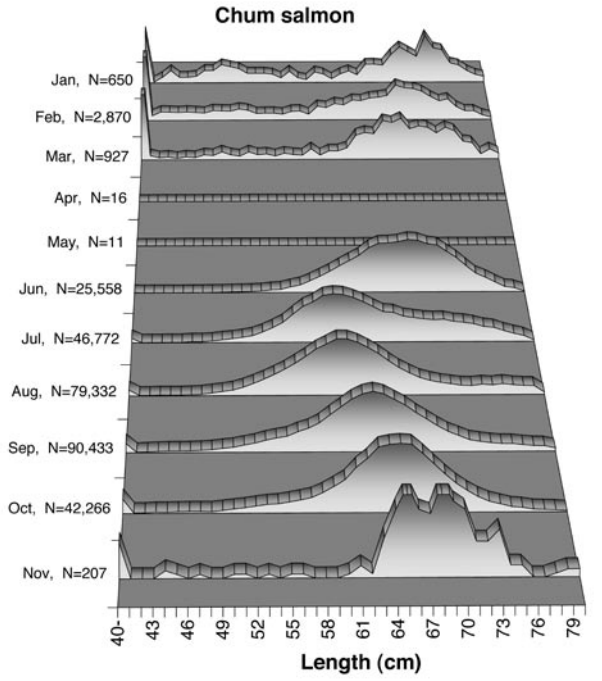


Figure 3. Chum salmon proportions at length by month as taken in the pollock fishery, 1998-2006 combined. Month and sample sizes are shown in the left axis labels.

frequency data. Chinook salmon are commonly taken incidentally by pollock trawl gear during both A (January-May) and B (June-December) seasons. Chum salmon are primarily taken during the B season. Day-night differences in pollock behavior and catchability are apparent from these data. Both pollock and salmon have somewhat higher catch rates during midday, but salmon rates drop (relatively speaking) more during night (Fig. 1). The nocturnal behavior of salmon, combined with the pollock fishing practices, decreases the relative rate of salmon bycatch. This could be due to diurnal patterns of salmon being more associated with the upper water column at night.

The seasonal size composition of Chinook salmon in the pollock fishery shows two modes, one at about 52 cm and the other at about 66 cm during the winter months with some indication of increasing size within the year (Fig. 2). From July to September, the smaller mode is less apparent but does appear again in October at about 49 cm.

For chum salmon, the seasonal size composition in the pollock fishery is unimodal, with apparent growth from a mode at about 60 cm in July to 66 cm by October (Fig. 3). Length frequencies from other times of year are based on relatively fewer samples and tend to be less than 40 cm. Interestingly, chum salmon from June have a modal value of about 68 cm, substantially larger than the mode of approxi-

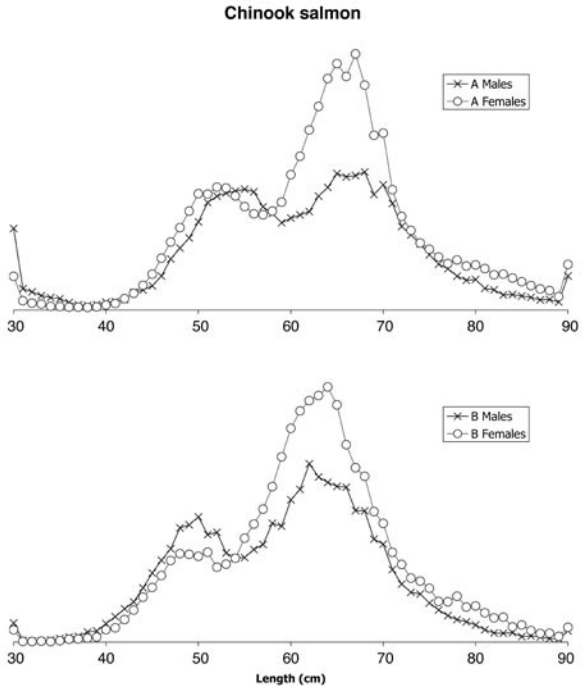


Figure 4. Chinook salmon proportions at length by sex for the A season (above) (Jan-May, 57% females from 84,099 samples; top panel) and B season (below) (June-Dec, 55% females from 66,361 samples; bottom panel) as taken in the pollock fishery, 1998-2006 combined.

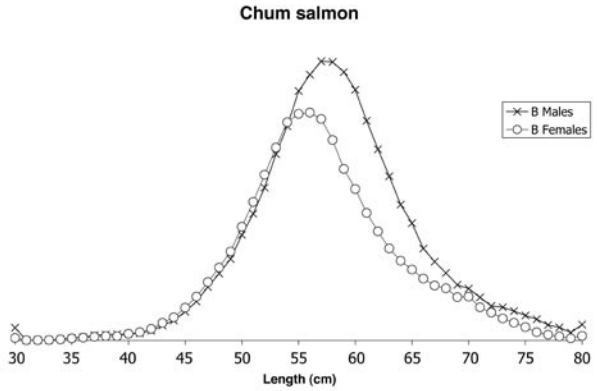


Figure 5. Chum salmon proportions at length by sex for the B season (June-Dec, 44% females from 287,933 samples) as taken in the pollock fishery, 1998-2006 combined. Chum salmon are much less prevalent (~1% of total chum catch) in A season hence length frequency samples from those months are omitted.

mately 60 cm observed in July and subsequent months (with obvious growth). This could be due to the fact that in 2006 the highest levels of chum bycatch were recorded in June (presumably this represents the bulk of samples) and that conditions in this year were anomalous.

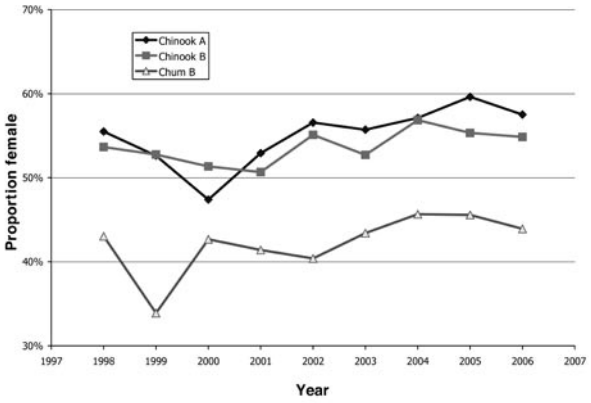


Figure 6. Sex ratios for Chinook and chum salmon over time. A and B seasons are shown for Chinook since there are significant catches in each of these seasons, chum salmon are primarily taken incidentally during the summer-fall (B) season.

The sex ratio of Chinook salmon bycatch in the pollock fishery favors females over males, particularly in the size range greater than 55 cm (Fig. 4). Chinook less than that size tend to be males more than females, particularly during the summer and fall (B season). Chum salmon have an opposite pattern with more males overall and with females appearing smaller than males (Fig. 5). Over time, the trends in these observed sex ratios have remained fairly consistent (Fig. 6). These patterns likely relate to the fact that female Chinook tend to mature at older ages than male Chinook salmon which return to spawning grounds earlier than the females. Analyses such as these provide insights on the question on what factors affect bycatch levels of salmon in the pollock fishery. It appears that increases in the bycatch of salmon in recent years are due to factors other than changes in the way that pollock fishing is conducted. Environmental conditions may have altered the distribution of salmon relative to the pollock fishery. For example, observations from inter-annual surveys by the BASIS program have shown significant increases in chum salmon in their survey area. Information from this study provides additional insight on patterns of bycatch by age, region and season. These results, combined with improved information on stock of origin and predictions of salmon abundance will provide managers with improved scientific advice for developing and evaluating management measures to reduce salmon bycatch in BSAI trawl fisheries.

By James Ianelli

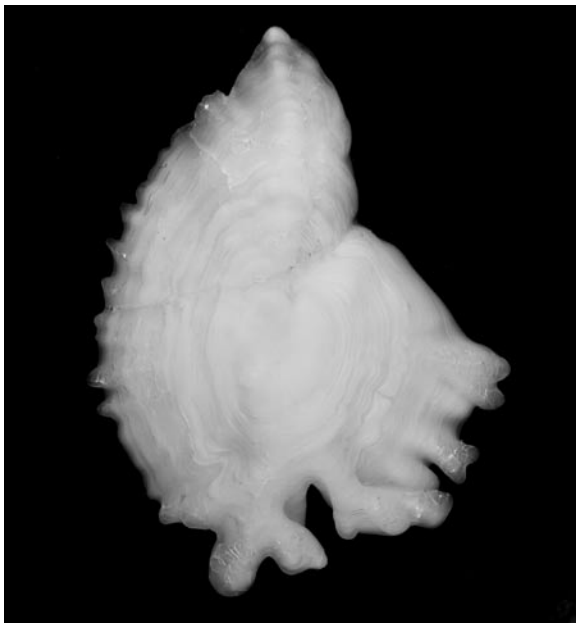
AGE & GROWTH PROGRAM

Oldest and Biggest Rockfish?

On 22 March, Mike Myers from the catcher-processor *Kodiak Enterprise*, brought an unusually large shortraker rockfish, *Sebastes borealis*, caught just south of the Pribilof Islands in the Bering Sea in to the AFSC's wet lab (see FMA Division Report). The fish was big, measuring 112 cm in fork length and weighing 27.6 kg. Was this the largest and oldest rockfish we have ever seen? For just about everyone in the lab this was probably true. Survey databases indicated no heavier rockfish was ever recorded and only one longer shortraker at 113 cm. However, observer databases indicated records of one shortraker rockfish at 119 cm and one shortraker weighing 30.6 kg.

But was this specimen the oldest? Shortraker rockfish are extremely difficult to age, but recently the Age and Growth Program developed new otolith ageing criteria for this species. The age agreed upon was 90 years old, with a possible age range of between 90 and 115 years. Is this the oldest rockfish specimen we have ever aged? Notable old specimens of rockfish include one other shortraker rockfish aged 116 years old, one specimen of rougheye rockfish, *Sebastes aleutianus*, aged 129 years old, and one specimen of Pacific ocean perch, *Sebastes alutus*, aged 100 years old. So this rockfish was neither the longest, heaviest, or oldest rockfish in our databases, but it was very close on all counts. It will probably be the heaviest and oldest rockfish seen by anyone lucky enough to have see it that day in March. Thank you, Mr. Myers, for bringing us this very interesting specimen.

By Dan Kimura and Charles Hutchinson



Pictured above is a photograph of an otolith from the shortraker rockfish described above that was aged 90 to 115 years.

Estimated production figures for 1 January through 31 March 2007.

Species	Specimens Aged
Giant grenadier	359
Greenland turbot	324
Alaska plaice	449
Northern rock sole	1,230
Bering flounder	258
Walleye pollock	3,849
Pacific cod	3,508
Atka mackerel	1,029
Pacific ocean perch	913
Rougheye rockfish	232
Shortraker rockfish	415

Total production figures were 12,566 with 3,710 test ages and 137 examined and determined to be unageable.