Auke Bay Laboratories (ABL)

MARINE SALMON INVESTIGATIONS

Pacific Salmon Commission Technical Committee Meetings

Auke Bay Laboratories (ABL) staff and contractors were involved in several bilateral Pacific Salmon Commission (PSC) meetings in January and February 2010. At the PSC post-season meetings held in Vancouver, British Columbia, 11-15 January, John Joyce participated in the Enhancement Subcommittee and full Transboundary Technical Committee (TBTC) discussions, Bill Heard and Michele Masuda were involved in deliberations with the Northern Boundary Technical Committee (NBTC), and contractor Alex Wertheimer was U.S. Co-Chair of the Total Mortality Working Group (TMWG) of the Chinook Technical Committee (CTC). Wertheimer also participated in TMWG and CTC discussions at the annual PSC meeting in February in Portland, Oregon, and Joyce attended a TBTC meeting in Whitehorse, Yukon Territory, in early March. A synopsis of bilateral technical issues for each of these groups is discussed below.

TRANSBOUNDARY TECHNICAL COMMITTEE

The Transboundary Technical Committee reviewed and discussed research and management activity on Taku, Stikine, and Alsek Rivers during 2009. Catch and management summaries by species and river system were presented for Chinook, sockeye, and coho salmon. The activities include smolt estimation through mark-recapture and code-wire tagging, adult weir counts, foot and aerial surveys, collection of genetic samples for baseline GSI work, and harvest data relevant to overage/underage treaty agreements.

Concurrent to the management summary, the enhancement subcommittee reviewed and summarized sockeye enhancement activity on the Taku and Stikine Rivers. Enhancement of sockeye salmon, now with formalized plans for each river, has been technically challenging and controversial. The plans tie enhancement directly to harvest sharing agreements, so there is a large investment in planning and monitoring enhancement activity. Specific issues related improving success in Taku River enhancement through extended smolt rearing and redesigning egg take strategies to improve Stikine River enhanced production. Most of the enhancement subcommittee's time during the Whitehorse meeting was dedicated to these panel directed activities.

In addition, committee chairs presented an update on the funding process for the PSC Northern Fund in 2010. Funds from this source went directly to pre-approved continuing NOAA ABL projects for Northern Boundary Sockeye (Jeff Guyon), Southeast Coastal Monitoring (Joe Orsi) and a small allotment to support University of Alaska Fairbanks/NOAA ABL work at Auke Creek (John Joyce). Also discussed were future Northern Fund projects for sockeye salmon enhancement and methods for improving Taku River Chinook salmon in-season management by expanding mark recapture programs.

NORTHERN BOUNDARY TECHNICAL COMMITTEE

The Northern Boundary Technical Committee meetings focused primarily on two issues: 1) catches of sockeye salmon in 2009 by the United States and Canada along the Dixon Entrance boundary area between Southeast Alaska and northern British Columbia; and 2) implementation of a blind test of known principal sockeye salmon stocks on both sides of the border comparing three analytical procedures. The analytical procedures include both DNA microsatellite and single-nucleotide polymorphism (SNPs) genetic analyses and scale pattern analysis (SPA) techniques for stock identification.

The U.S. Canada Pacific Salmon Treaty allows for specific rates of interception of sockeye salmon originating from Canadian Nass and Skeena Rivers that are caught in Southeast Alaska fisheries called the annual allowable harvest (AAH). To arrive at the appropriate harvest level of these stocks by Alaska fisheries the total annual sockeye runs to both Nass and Skeena Rivers must first be derived by determining the total Canadian catch (including First Nations catches), escapements to the rivers, and the Alaska catch. Sorting this out requires detailed stock composition analysis of sockeye catches on both sides of the border. Historically stock composition of samples from Canadian fisheries has been derived by DNA microsatellite analysis by Fisheries and Oceans Canada (DFO) and by SPA analyses from U.S. fisheries by the Alaska Department of Fish and Game (ADF&G). Presently, however, the ADF&G is planning to shift from SPA analysis to genetic-based SNPs analysis of catch samples from Alaska fisheries. A previous blind test between DNA and SPA analyses of known samples verified the utility of this earlier procedure, hence now the need for a new blind test comparing analyses of all three techniques.

One reason detailed annual stock composition analyses of these fisheries is necessary is that migration patterns vary from year to year, and stock composition of catches in specific fishery openings on both sides of the border fluctuate greatly within season and between seasons. While Nass and Skeena Rivers comprise the two main Canadian stocks, most Alaska stocks involved in these fisheries consist of a large number of much smaller sockeye stocks in the southern part of Southeast Alaska grouped together for analysis as the Alaska composite. Also, in some years depending on landfall patterns and specific migration routes of returning adult sockeye, significant numbers of Stikine River sockeye from central Southeast Alaska, Fraser River sockeye from southern British Columbia, and smaller west Vancouver Island sockeye stocks are also caught in these Northern Boundary fisheries.

A very low forecast for Skeena River sockeye salmon may preclude targeted fisheries on this stock in 2010. Roughly 80% of total sockeye returns to the Skeena River usually come from the headwaters of the Babine River system where a large artificial spawning channel development is the main driver of Babine production. Failure of ocean age-1 sockeye "jacks" to the Babine spawning channels in 2009, usually a dependable forecast tool, has Canadian officials concerned about returns for the coming season.

TOTAL MORTALITY WORKING GROUP

Recent Total Mortality Working Group and CTC meetings have focused on the required analyses necessary to implement a total mortality management regime for aggregate abundance-based management (AABM) fisheries for coastwide Chinook salmon fisheries as called for under the 2008 Treaty agreement. This involves a complicated and lengthy process of developing methods for translating the relationship between nominal landed catches of Chinook

salmon and the abundance indexes (AIs) for AABM fisheries into total mortality (TM) units. A CTC model involving stock-specific brood year exploitation rates for indicator stock using cohort analysis procedures provides a variety of stock-specific statistics including exploitation rates and maturation rates that are combined with data on catches, escapements, Chinook non-retention mortality, sublegal mortality from hook and line gear (shaker mortality) and enhancement to provide annual calibrations of the model that determines the appropriate AI for each year. The developed AIs then determine the allowable landed catch (LC) of Chinook salmon for three AABM fisheries (Southeast Alaska, northern British Columbia, and west coast of Vancouver Island) as shown in Table 1 of Annex IV of the Treaty.

Applying TM units into landed catch (LC) equivalents requires careful evaluation and development of a suite of variable metrics including the probability of a fish surviving to maturity in the absence of fishing, converting different types of fishing mortalities into common values within and between gears, and considering relationships between different minimum size limits restrictions in different fisheries. These new metrics subsequently will be used by CTC to calculate the allowable TM for both pre-season and post-season estimates for each AABM fishery along with development of a new revised TM Table 1. This new table will define the allowable catch in each fishery as determined by the annual AI. Significant changes in allowable Chinook harvests in AABM fisheries are possible.

The continued evaluation and refinement of this process is still ongoing by the TMWG with the intention of completion by late 2010 in time for potential application of TM fisheries for Chinook salmon during the 2011 season. Depending on the final outcome of TM management projections, implementation will follow any new Pacific Salmon Commission directives.

By Bill Heard, Michelle Masuda, John Joyce and Alex Wertheimer

NOAA Aquaculture Program Coordination Meeting

The NOAA Aquaculture Program staff met 28 February 2010 with Regional Aquaculture Coordinators from the NMFS Northeast, Southeast, and Southwest Regional Offices and with NMFS Science Center aquaculture points of contact for the Southwest, Southeast, and Alaska Fisheries Science Centers. Also participating in the meeting were representatives from the Northeast Fisheries Science Center Milford Laboratory, Northwest Fisheries Science Center (NWFSC) Montlake and Manchester Laboratories, the National Ocean Service Beaufort Laboratory, and the NOAA Sea Grant Aquaculture Program. The meeting was held at the temporary Southwest Fisheries Science Center's (SWFSC) Torrey Pines Facility in La Jolla, California.

Michael Rubino, NOAA Aquaculture Coordinator, led off the meeting with an overview of administration and ongoing activities within the National Program. He reviewed the small increases in program funding with a cautious outlook for moderate future increases. Dave O'Brien from program staff discussed budgets in more detail including moderate increases for research funding that is now available for aquaculture centers at the Northeast and Northwest Fisheries Science Centers with lesser amounts for some projects at other Science Centers and Laboratories. Susan Bunsick also from NOAA discussed current steps underway to help the agency develop a new national policy for sustainable marine aquaculture. Under guidance from NOAA Administrator Jane Lubchenco, key steps in this process involve a series of six listening sessions NOAA will be holding around the country in April and May to solicit recommendations from industry and the public. One of these listening sessions will be held at the Seattle Aquarium on 22 April. A draft of the new policy will be available later this year for public comment.

Regional Coordinators and participants from Sea Grant, NMFS Science Centers, and various laboratories also gave reports on aquaculture programs including current research activities in their particular areas. Bill Heard gave an overview of AFSC aquaculture activities including a review of the king crab stock enhancement research at the Kodiak and Newport Laboratories and the Chinook salmon stock enhancement research at the Little Port Walter Marine Station. The king crab research involves the University of Alaska and is associated with the Alutiiq Pride Shellfish Hatchery in Seward. Heard briefly reviewed Alaska's moderate shellfish industry and the large-scale salmon stock enhancement program operated by the five Regional Aquaculture Associations throughout the state.

Usha Varanasi, Director of the NWFSC and acting Director of SWFSC, spoke to the group about the importance of developing sustainable and economically viable aquaculture, including stock enhancement, in helping the United States meet current and future needs for safe abundant seafood.

The Aquaculture Coordinator's meeting was held in conjunction with the World Aquaculture Society's Aquaculture 2010 Meeting in San Diego, California, 1-5 March. NOAA Aquaculture Program staff and researchers across the agency gave over 25 presentations on a wide range of issues including ocean acidification and shellfish, alternatives to fish meal in aquaculture feeds, advances in stock replenishment/ enhancement, fish health, aquaculture extension, market efficiency, and policy. NOAA officials also participated in a Town Hall meeting with other federal agencies and aquaculture industry.

By Bill Heard

Fisheries Monitoring & Analysis (FMA) Division

Twenty Year Anniversary of the Domestic Groundfish Observer Program

Twenty years ago Amendment 13 to the Bering Sea/Aleutian Islands (BSAI) Groundfish Fisheries Management Plan (FMP) and Amendment 18 to the Gulf of Alaska (GOA) Groundfish FMP implemented the domestic North Pacific Groundfish Observer Program (Observer Program) for Alaska groundfish fisheries. Upon publication of the final rule governing the Observer Program in 1989, tremendous effort, cooperation, and dedication were required of staff at the AFSC and NMFS Alaska Regional Office, observer providers, observers, and industry to ensure that in less than a 6-month turnaround time, all was in place for the Observer Program to move forward with domestic observers deployed to vessels in January 1990. Since that time, the North Pacific Groundfish Observer Program has made many accomplishments and advances, serving as an example both nationally and internationally for successful fisheries management.

The success of the Observer Program and importance to its many constituents culminated in the establishment in 2005

of the Fisheries Monitoring and Analysis Division (FMA) with the Observer Program at its core (July-September 2005 issue of the *AFSC Quarterly Report)*. This change improved the Program's ability to provide high quality data to end users through training and deploying observers into the field, monitoring data collected while observers are still deployed, and finalizing the data during the debriefing process.

A proud accomplishment of the Program is its safety record. Each year the Program deploys approximately 400 observers who spend roughly 36,000 days at sea collecting data. Most people complete their work and return without incident. However, two tragic observer fatalities, one in 1990 and another in 2007, furthered awareness of the inherent dangers faced by observers at sea and the commitment to safety as the most important issue for the Observer Program.

Extensive advancements have been made in the area of data transmission over the past 20 years. In 1990, raw data were written on plastic deck sheets and later transferred to paper forms. The catch and fishing effort data were summarized into a weekly catch report which was submitted via fax machine, telephone, telex, or as a coded radio message. Observers reported the area(s) where the vessel fished and a summary of the week's catch by species or species group. In 1997, the Program launched a custom at-sea software application for data transmission to Seattle. Now, observers record raw data on deck forms printed on write-in-the-rain paper. The deck forms are retained to preserve the raw data. Currently, approximately 80% of our data are submitted electronically, and these data are entered directly from the deck forms to FMA's custom at-sea software for transmission to Seattle. The custom software also allows staff to review data as they are submitted and to communicate directly with observers at sea via text messages allowing staff to quickly address any questions regarding the data. Approximately 20% of data are not submitted electronically but are transcribed from the deck forms to paper forms and submitted via fax. These data are collected on smaller vessels that do not have capacity to install the additional equipment needed to support the at-sea software.

When the Observer Program first began, all data were verified and corrected manually during debriefing interviews with the observer to ensure data quality. The verified data were then submitted to keypunchers for entry to our final database where additional automated error checks were performed. Today, numerous error checks are run on the data even while the observer is still at sea. FMA staff can communicate with observers and clear up any potential problems quickly. It used to take about a year to finalize data from the previous calendar year and now, thanks to advances in technology, the previous year's data are finalized by the end of March.

A fisheries observer measures Pacific cod onboard a catcher trawler.

While many aspects of the Observer Program have changed since its inception and with significant restructuring planned for the future, much about the Program remains the same. The fundamentals of commercial fishing and collecting data onboard fishing vessels remain largely unchanged. Observers still collect samples using standard blue baskets wearing the standard raingear and neoprene boots; and the experience gained while working as an observer has launched the career of many aspiring fisheries biologists. Although sampling protocols have been refined, the Program maintains a database with more than 30 years of data from the Bering Sea-Aleutian Islands and the Gulf of Alaska. Personnel have come and gone, but eight of the staff members onboard in 1990 remain with FMA, while many former Program staff now work in other divisions at the AFSC or elsewhere for NOAA.

The structure of the domestic Observer Program originally was modeled after the Supplemental Observer Program created in 1985 for the Foreign Fisheries Observer Program. This model was based on a method for foreign governments to pay for observers placed on their ships without paying fees directly to the U.S. Government. The borrowed structure for the domestic Observer Program was intended as an interim solution but in fact has persisted for 20 years. As such the Program has faced a number of longstanding concerns that result primarily from its underlying structure. Planning for restructuring the Observer Program has been underway for several years. Implementation of the restructuring is a large and complex undertaking, and the projected timeline is dependent on several steps, many of which are associated with the normal North Pacific Fishery Management Council and rulemaking process. Council final action is tentatively scheduled for October 2010, with the associated rulemaking developed through 2011. Development for a contract of this projected scope is expected to take about 2 years to complete, with the potential implementation of a newly restructured Observer Program in 2013. (Further information on restructuring is reported in the July-September 2009 issue of the *AFSC Quarterly Report*.)

Looking back, it is remarkable to see how much the Observer Program has developed in the past 20 years. We look forward to what the next 20 years will bring.

By Allison Barns and Russ Nelson

Habitat & Ecological Processes Research (HEPR)

Loss of Sea Ice Funding Received

The Alaska Fisheries Science Center (AFSC) received $1.2 million for loss of sea ice research in FY 2010. These new funds will be used to expand the southeast Bering Sea bottom trawl survey northward to the Bering Strait and to conduct ice seal research.

The AFSC's Groundfish Assessment Program will complete the northward expansion of the trawl survey. With this expansion, all of the eastern Bering Sea shelf within U.S. waters will be surveyed. The full sampling capabilities of the existing trawl survey will be replicated on the northern extension including bottom trawling and plankton and oceanographic sampling. The project also will support development of an annotated checklist of epibenthic marine invertebrates for the Bering Sea and Arctic Ocean because these species are more common farther north.

The AFSC's Polar Ecosystems Program will begin a 5-year plan to conduct aerial abundance surveys for ribbon, spotted, and bearded seals in the Bering Sea and in the Sea of Okhotsk and for ringed seals in the Beaufort, Chukchi, and northern Bering Seas. The abundances of these species, protected under the Marine Mammal Protection Act and considered for listing under the U. S. Endangered Species Act , are very poorly documented. Preparation and detailed survey design will be conducted in 2010 and 2011 for the ribbon, spotted, and bearded seal surveys. These surveys will be conducted in both U.S. and Russian waters in 2012 and 2013, and the data will be analyzed in 2014. In addition, a design for surveys for ringed seals will be developed and implemented to commence in 2014.

By Mike Sigler

Ocean Acidification Funding Received

The AFSC received $380,000 for ocean acidification research in FY 2010. These new funds primarily will be used to conduct species-specific physiological research. The species-specific physiological response to ocean acidification is unknown for most marine species. Lacking basic knowledge, research will be directed toward several taxa including king crab, euphausiids, coldwater corals, walleye pollock, and Pacific cod. The research will be conducted at the Kodiak, Auke Bay, and Newport Laboratories. Work also will begin on incorporating results into a king crab bioeconomic model; this work will be completed by the AFSC's Socioeconomics Assessment Program in Seattle.

By Mike Sigler

National Marine Mammal Laboratory (NMML)

ALASKA ECOSYSTEMS PROGRAM

Probabilistic Modeling of Northern Fur Seal Movement

In the past 5 years, the Alaska Ecosystems Program (AEP) at the National Marine Mammal Laboratory has conducted several studies of northern fur seals (*Callorhinus ursinus*) using satellite-telemetry devices, including assessment of pup migration distribution, fine-scale assessment of dive behavior relative to foraging location, and determination of female foraging location relative to diet signatures in stable isotope analysis. All of these studies relied on data collected by satellite-telemetry devices to determine the animals' locations while away from the rookery.

No matter what the intended use of the collected satellite data, there is often a host of problems that must be overcome to make use of the recorded locations. First, the locations are recorded with error. The current method for determining locations depends on the timing of signals received by a passing satellite. The satellite uses the difference in the timing of received messages to calculate

Figure 1. A fitted track with hourly-predicted locations for two female northern fur seals from the Vostochni rookery, St. Paul Island, Alaska; the light gray symbols represent the observed locations received by the satellite, and the darker tracks are obtained by making hourly predictions and connecting the estimated locations.

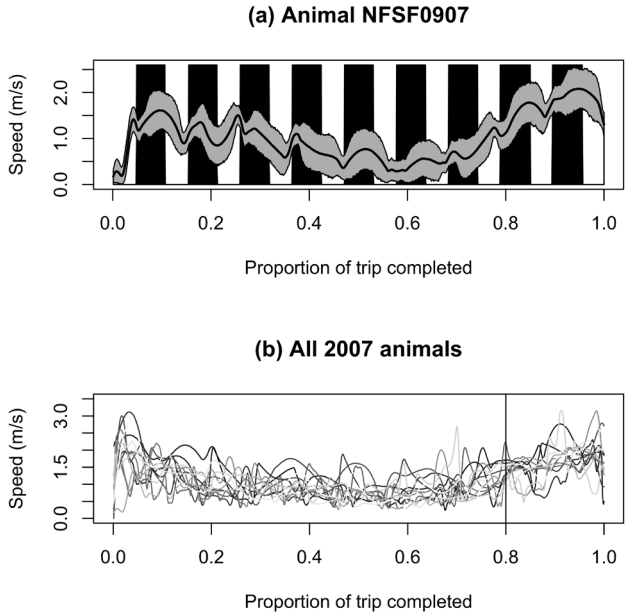

Figure 2. Estimated speed in meters/second (m/s) for a) a single northern fur seal; and b) a group of northern fur seals; the black bars represent nighttime hours.

an approximate location. The error in this estimate can range from 150 m up to several kilometers, depending on the number of signals received. Fortunately, these locations can be labeled with a location-quality class that gives an estimate of the error. The second major issue is that location times are often not recorded directly with times of interest (e.g., at times of known diving).

In order to overcome these two major issues and make telemetry data more useful, AEP researchers have been developing statistical models capable of accounting for location error, as well as predicting locations for any desired time. Readers who are interested in the mathematical details of these models can refer to the *Ecological Society of America Ecology* journal article by Johnson et al. (2008) for a more rigorous description. The continuous-time correlated random walk (CTCRW) model works by mathematically describing the velocity of the animal. By describing how the animal's location changes with time, we can produce a model of locations by essentially summing up the "steps" that the animal takes. Within the mathematical description, we can make the average "steps" depend on parameters measured along with location, such as diving depth, number of dives, or sea-surface temperature. All of these variables might help describe how northern fur seals are foraging relative to their environment.

Recently we have been developing an add-on package for the freely available R statistical software (R Core Development Team 2009) on the web at http://www.r-project.org/ to process telemetry locations with the CTCRW model. The package "crawl" was developed by the AEP for the purpose of fitting these models, making location predictions, and simulating possible paths the animal may have taken given the locations that were observed. The software uses the fast Kalman filter to perform the calculations necessary for these operations. To use the software, first R must be installed. Then, one can install the add-on package from within R itself. Both are available from the Comprehensive R Archive Network (CRAN), on the web at http://cran.r-project.org/.

Figure 1 illustrates a fitted track with hourly-predicted locations for two female northern fur seals from the Vostochni rookery on St. Paul Island, Alaska. The model fit in this example is just a constant mean velocity. However, one can easily add in time-varying covariates such as time itself. The AEP is currently exploring northern fur seal movement relative to a diurnal cycle. Figure 2 illustrates estimated speed for both a single animal and a group of animals. Changes in speed seem to occur at transitions between night and day. Speed is generally decreasing at dawn hours and increasing at dusk. Because northern fur seals generally forage at night, it seems that foraging is linked with higher rates of travel. This is contradictory to the usual area-restricted search postulated for foraging animals, and AEP researchers are examining whether this is a general pattern.

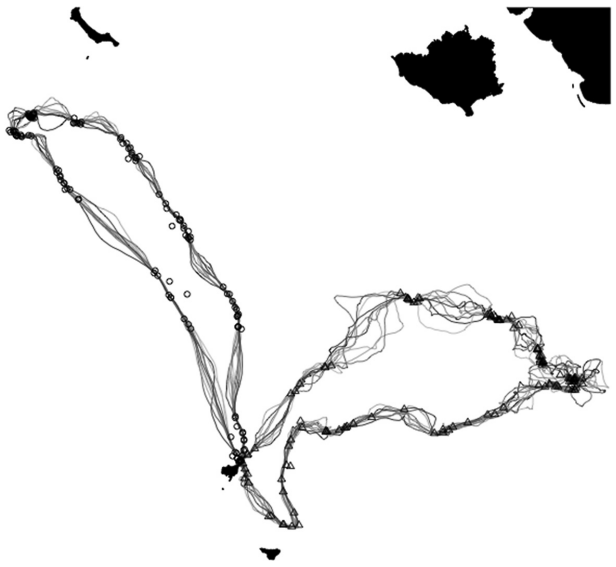

Figure 3. Track simulations for two female northern fur seals from the Vostochni rookery, St. Paul Island, Alaska.

Another aspect of this modeling framework is the ability to simulate a track from the posterior predictive distribution of the animal's true path. In essence, the crawl package can simulate locations for times when the animal was not located. This is slightly different from making a prediction for the time of interest. The prediction is the single best estimate of location, while the simulated location represents only one possible value. If we model multiple tracks, we can get a sense of the uncertainty in the location estimation. Figure 3 shows track simulations for the same two animals that were illustrated in Figure 1.

In recent months, AEP researchers have been using the posterior predictive simulation to characterize space use of northern fur seals in the Bering Sea. By simulating locations at the time the dives occurred, we are able to estimate dive intensity over the Bering Sea shelf. Figures 4a-c illustrate an estimate of dive intensity for 13 animals that were tagged in October 2007. The visual correction in Figure 4c is accomplished by making pixels more transparent if uncertainty is high. This gives a better overall picture of the spatial dive-intensity estimate.

By Devin Johnson

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

How Fast Do Whale Populations Grow? Investigating the Plausibility of Humpback Whale Rates of Increase from Life-history Data

The rate at which biological populations grow is a quantity of considerable interest in conservation and management and is often used in assessments of the status and future of wildlife populations. During the past several years, the rate at which large-whale populations grow has been a matter of debate in the Scientific Committee (SC) of the International Whaling Commission (IWC) because many scientists have questioned the plausibility of some reported rates of increase (ROIs); some are in excess of 15% per year or even as high as 30%! These ROIs were estimated from time series of abundance estimates and were proposed for use in the IWC's comprehensive assessments of large-whale populations.

The ROI of any population of animals is fundamentally constrained by biological parameters such as survival, age at first parturition, and birth rate. Therefore, the combination of empirical knowledge of these parameters and use of population models provides an opportunity to assess the plausibility of estimates of ROI from time series of abundance estimates. Previous attempts by the IWC to assess the maximum rates at which humpback whale (*Megaptera novaeangliae*) populations grow used theoretical values for biological parameters or, because of the lack of empirical

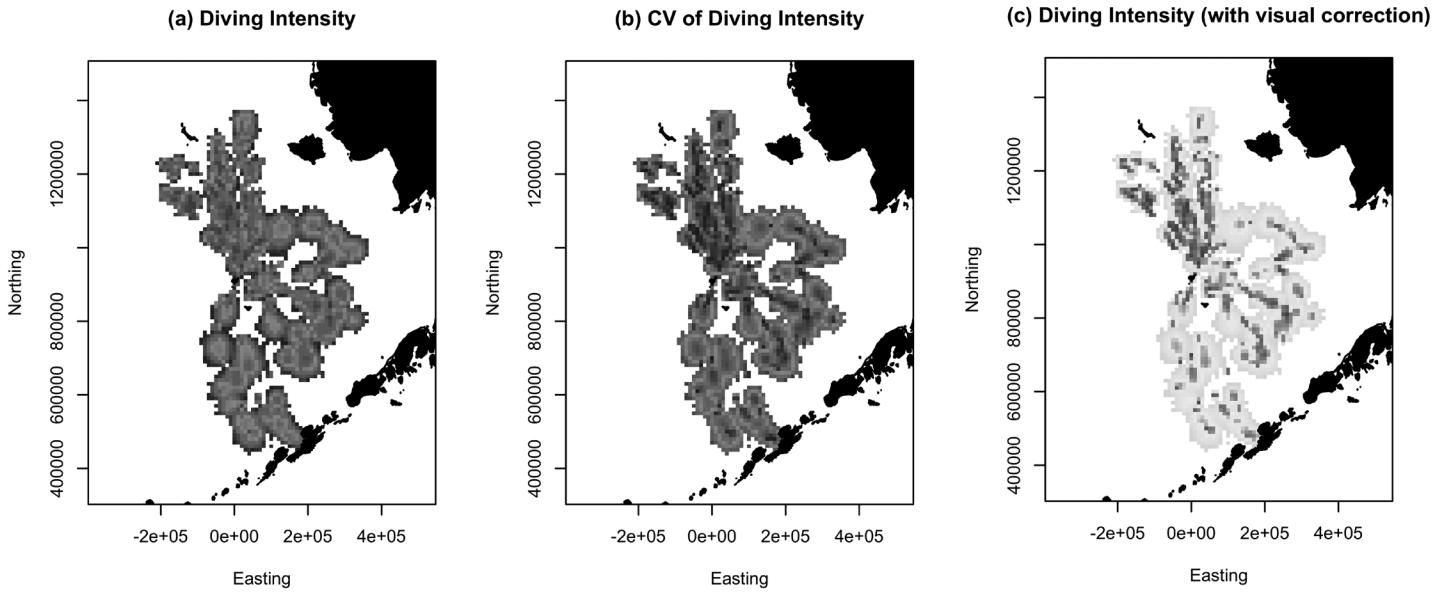

Figure 4. Estimate of dive intensity for 13 northern fur seals tagged in October 2007, including a) a heat map of diving intensity; b) the CV (Coefficient of Variation) of the estimate of diving intensity; and c) a "visually corrected" estimate of diving intensity.

estimates, made unrealistic assumptions for certain parameter values. For example, the calf (age 0-1 year) survival probability, which in mammal species is generally lower than that of older age classes, was assumed to be equal to the non-calf survival probability. In addition, no consideration was given to incorporating uncertainty (measurement error) in parameter estimates when computing plausible rates of population growth. Results of previous studies suggested that the maximum ROI in humpback whales was as high as 14.8% per year.

In our paper, Zerbini et al. (2010), recently published in the journal *Marine Biology*, we recomputed plausible rates of population growth for humpback whales. This study, developed by the National Marine Mammal Laboratory's Cetacean Assessment and Ecology Program, was based on a review of existing estimates of humpback whale life-history parameters worldwide. The most optimistic estimates, along with estimates of their sampling variability, were used as input parameters in a population model, and a distribution of maximum plausible ROIs was computed using Monte Carlo methods. The most favorable scenario resulted in a mean ROI estimate of 8.6% per year (95% CI = 5.0–11.4%/year). In our paper, we propose that the upper 99% quantile of the simulated ROI distribution (= 11.8%/year) be established as the maximum plausible ROI for humpback whales, and we recommend that this value be used to ground truth estimates of rates of population growth from time series of abundance estimates. We also recommend this maximum value be established as an upper boundary for growth-rate parameters in population models for humpback whales. Finally, we discuss possible sources of positive and negative biases in the existing estimates of life-history parameters and conclude that it is difficult to evaluate how these biases could affect estimates of ROI without additional data. The methods described in this study are relatively straightforward and can be applied to other species for which life-history parameters are available.

By Alex Zerbini, Phil Clapham, and Paul Wade

POLAR ECOSYSTEMS PROGRAM

Blood-Oxygen Capacity of Ribbon, Spotted, and Bearded Seals

Hemoglobin (Hb) concentration and packed cell volume (PCV) are indicators of oxygen storage and transport capacity in the blood. Deep-diving mammals generally have higher PCV and Hb levels than terrestrial mammals, allowing them to store more oxygen, make deep dives, and stay submerged while foraging. The National Marine Fisheries Service has recently been petitioned to list the four species of ice-associated seals found in Alaska waters (i.e., ribbon, spotted, bearded, and ringed seals) as endangered or threatened under the Endangered Species Act. The petition was primarily based on concerns about global warming and the projected loss of sea-ice habitat. Ice-associated seals give birth and nurse their pups on shore-fast and pack ice; pups use sea ice for resting between foraging bouts. Warming oceans, loss of sea ice, and other environmental perturbations caused by Arctic climate change could affect abundance, distribution, and composition of prey. A loss of suitable sea ice in traditional weaning grounds could isolate seals from important prey communities, requiring longer or more frequent dives. Therefore, information on blood-oxygen capacity may be important for assessing how these seals might be influenced by a changing environment. Existing data on PCVs and Hb levels in these seals are scarce or nonexistent, and information on blood-oxygen capabilities may be important to assess how seals respond to a changing environment.

In May and June 2009, members of the Polar Ecosystems Program sampled ribbon (*Histriophoca fasciata*) and spotted (*Phoca largha*) seals from the Bering Sea and bearded seals (*Erignathus barbatus*) from the Chukchi Sea (Fig. 5). We collected blood samples and measured Hb concentration, PCV, and mean corpuscular hemoglobin concentration (MCHC) in 31 ribbon and 29 spotted seals, including individuals from all age and sex classes. Only three

Figure 5. Capture locations of ribbon, spotted, and bearded seals in the Bering and Chukchi Seas in May and June 2009.

bearded seals were sampled; all three were males, with one adult and two subadults. Mean Hb levels for ribbon, spotted, and bearded seals were 20.80±1.88 grams/deciliter (g/dl), 17.98±3.14 g/dl, and 29.49±2.43 g/dl, respectively. Mean PCVs for ribbon, spotted, and bearded seals were 62.5±3.6%, 56.2±5.3%, and 54.7±1.5%, respectively (Fig. 6).

In our sample, PCV was highest in ribbon seals for all ages and sexes (Fig. 7). Ribbon seals also had higher Hb values than spotted seals across age groups. These results may be related to the fact that ribbon seals are deeper divers than spotted or bearded seals. Hematology values have been compared in harp (*Phoca groenlandica*) and hooded (*Cystophora cristata*) seals; hooded seals, which are deeper divers, had higher PCV levels than harp seals. Hb and PCV levels were very similar between males and females for both ribbon and spotted seals.

We have very limited data for bearded seals (n = 3; all males), but Hb levels were much higher in these three seals than in ribbon or spotted seals (Fig. 7). This raises additional questions because bearded seals are the shallowest divers of the three species and presumably do not need high levels of hemoglobin to assist with deep diving. However, in California sea lions, hemoglobin and MCHC increased with mass, and bearded seals are considerably larger than ribbon and spotted seals.

A trend in which both Hb and PCV values increased with age from young-of-the-year to subadults and then decreased from subadults to adults has been observed in harbor seals. Our results bear some similarities to this pattern, but larger samples will be required to confirm whether any of the patterns and differences that we found are significant and to relate the patterns to potential responses of these species to a warming climate.

By Heather Ziel, Michael Cameron, Tracey Goldstein, Shawn Johnson, and Peter Boveng

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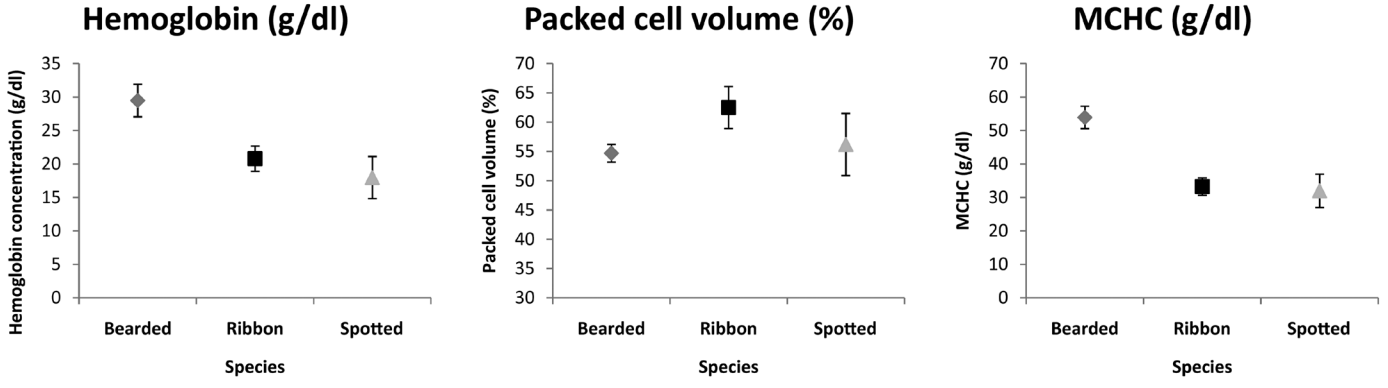

Figure 6. Mean hemoglobin concentration, packed cell volume, and mean corpuscular hemoglobin concentration (MCHC) for bearded, ribbon, and spotted seals.

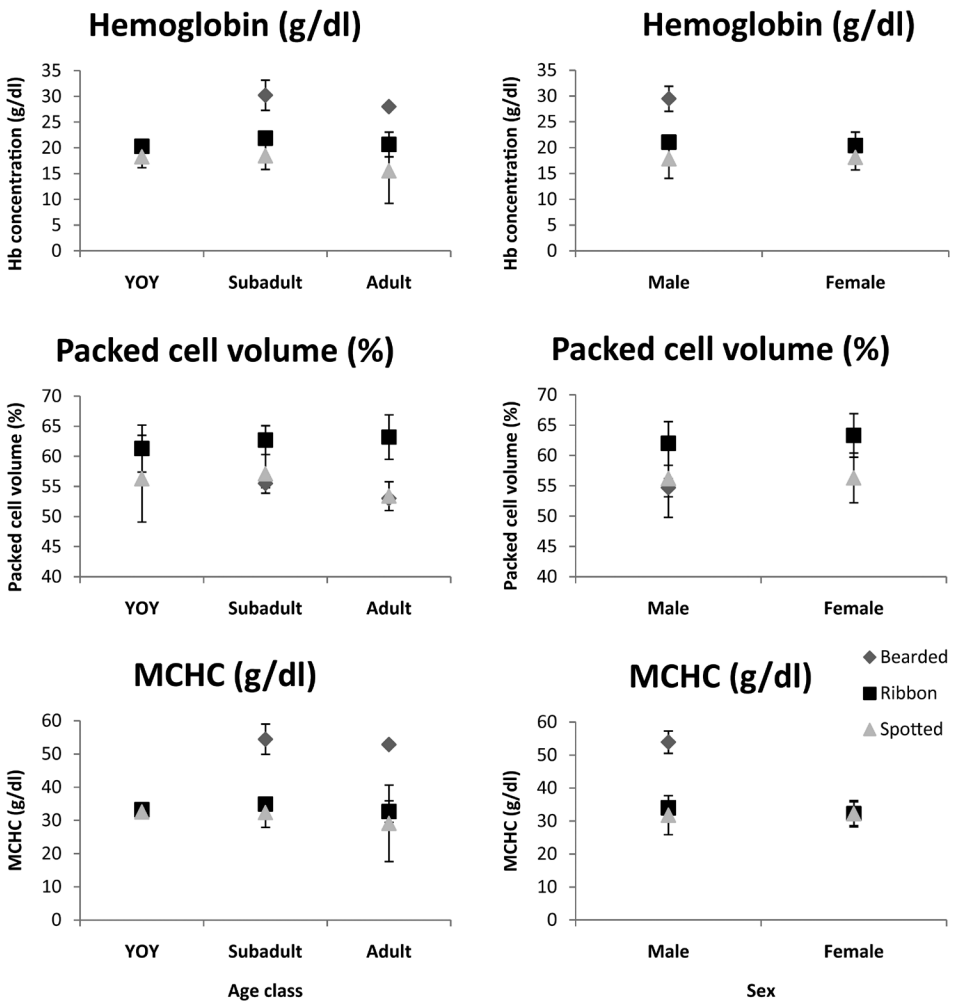

Figure 7. Hemoglobin concentration, packed cell volume, and mean corpuscular hemoglobin concentration (MCHC) for bearded, ribbon, and spotted seals compared among age classes and between sexes.

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Resource Assessment & Conservation Engineering (RACE) Division

MIDWATER ASSESSMENT & CONSERVATION ENGINEERING (MACE) PROGRAM

Winter Surveys in the Gulf of Alaska

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program conducted another in a series of winter echo integration-trawl surveys aboard the NOAA ship *Oscar Dyson* in the Gulf of Alaska (GOA). These surveys provide updates on the abundance, distribution, and biological composition of prespawning walleye pollock (*Theragra chalcogramma*). Areas surveyed between 22 February and 9 March 2010 included the Shumagin Islands (Shumagin Trough, Stepovak Bay, Renshaw Point, Unga Strait, and West Nagai Strait), Sanak Trough, Morzhovoi Bay, Pavlof Bay, Kenai Peninsula bays, Prince William Sound, and Marmot Bay. Areas surveyed between 18 and 30 March were Shelikof Strait and the shelfbreak east of Chirikof Island. All surveys were conducted 24 hours per day.

Preliminary survey results indicated that the 2010 walleye pollock abundance in the Shumagin Islands area was roughly one-third of the 2009 estimate (a 5-year high) but was more comparable to what was observed in 2007. Dense juvenile schools were detected in easternmost Shumagin Trough (Fig. 1). Adult walleye pollock densities were again low off Renshaw Point, where the highest quantities of adults had been detected prior to 2007. The length distribution of walleye pollock in the Shumagin Islands area consisted primarily of fish between 27 and 43 cm fork length (FL; age 3, 4, and 5), and a mode at 23-cm FL (age 2). In Sanak Trough the 2010 biomass estimate fell between the 2008 and 2009 estimates. The majority of the biomass in Sanak Trough was located over the center of the trough (Fig. 1) and the size composition was unimodal, with most fish between 50 and 70 cm FL. Morzhovoi Bay biomass estimates were less than two previous surveys (2006 and 2007) and few pollock were encountered in Pavlof Bay.

The preliminary walleye pollock biomass estimate in Shelikof Strait was almost twice that reported in the previous 3 years, and for the first time since 2000, the highest fish densities were observed along the west side of the strait proper between Cape Unalishagvak and Cape Kuliak (Fig. 2). Dense aggregations were also detected along the eastern sides of the southernmost transects. In the Shelikof Strait area, the size composition consisted of a mixture of 20-40 cm FL (age 2 and 3), and larger adult fish. The latter dominated the deepest part of the strait between Cape Kuliak and Wide Bay, and the younger fish dominated elsewhere. In Marmot Bay at Kodiak Island, dense midwater pollock schools were detected to the northwest of Spruce Island and in Spruce Gully. The size composition for Marmot Bay was dominated by fish measuring 40-50 cm FL. The 2010 pollock biomass estimate along the GOA shelfbreak in the vicinity of Chirikof Island was substantially higher than the 2009 estimate but still approximately half that seen in 2008.

All of the bays along the southern edge of Kenai Peninsula that were surveyed

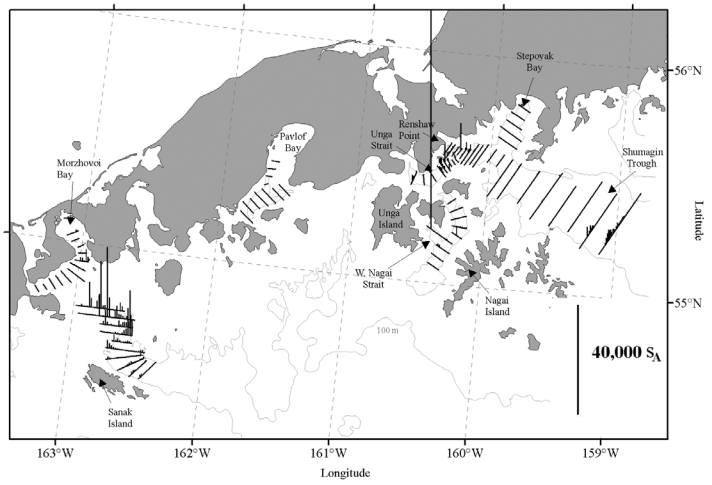


Figure 1. Acoustic backscattering (S_A) attributed primarily to walleye pollock (vertical lines) along transects during the February 2010 acoustic-trawl surveys of the Shumagin Islands and Sanak Trough in the Gulf of Alaska.

contained aggregations of mostly adult walleye pollock, as did the eastern side of Prince William Sound (Fig. 3). Most of the fish in Prince William Sound were below 400 m in the water column. This was the first winter MACE survey of the Kenai Peninsula bays and Prince William Sound using an echosounder that effectively sampled deeper than 400 m.

Preliminary analysis of maturity stages indicated that survey timing was appropriate for all areas except Sanak Trough and Morzhovoi Bay, where relatively large percentages of the post-spawning adult females were caught.

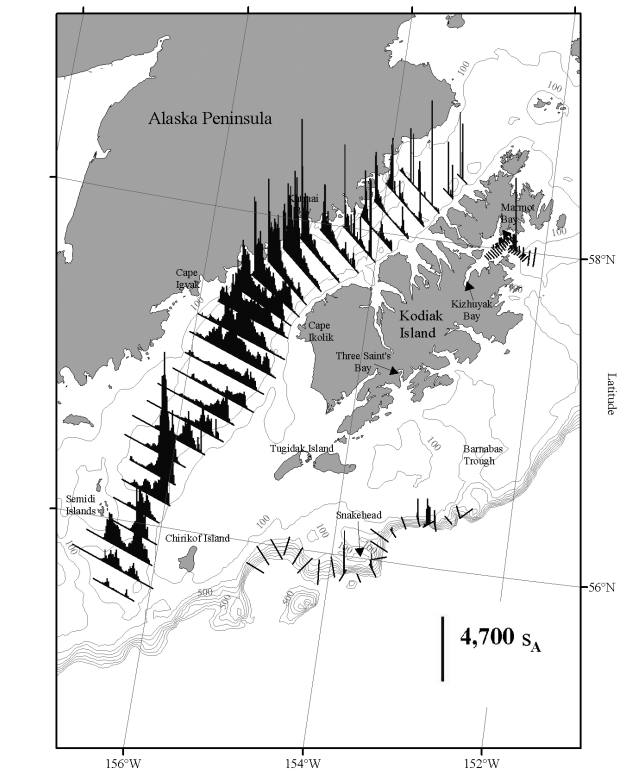
By Michael Guttormsen

GROUNDFISH ASSESSMENT PROGRAM

Habitat Researchers Participate in Advanced Technology Workshop

Members of the RACE Division's Habitat Research Group (HRG) participated in the NOAA Office of Coast Survey's (OCS) 2010 Field Procedures Workshop held in Seattle on 26-28 January. This is an annual national meeting concerned with review and discussion of protocols for the acquisition and processing of hydrographic data by NOAA.

A total of 50 technical presentations and open discussions occurred during the 3-day workshop. Part of the workshop focused on better understanding other users' needs for the data OCS acquires and how best to move forward in support of the Integrated Ocean and Coastal Mapping (IOCM) initiative. The IOCM initiative is an emerging NOAA-wide effort to acquire, manage, integrate, and disseminate ocean and coastal geospatial mapping data. This effort seeks to provide easy access to these data and their derivative products for a diverse group of public and private end users. To be successful, IOCM requires a high level of coordination within the agency and with other groups engaged in seafloor mapping. The NOAA IOCM vision is to "Map once, use many times." To this end, Bob McConnaughey and Meghan McGovern were invited to discuss HRG research that is looking at the utility of acoustic seabed backscatter for characterizing essential fish habitat (EFH), while at the same time producing new bathymetric data for nautical chart updates in areas with outdated or nonexistent information. Their joint presentation titled "Using quantitative backscatter in fish habitat models" provided background and rationale for the fisheries research component as well as technical considerations related to acquisition and processing of backscatter data from hydrographic multibeam echosounders. The presentation was intended to help the OCS community better understand program requirements for backscatter and how they can be met. Backscatter acquisition and processing currently is not an OCS specialty, and there is not a specific set of requirements or deliverables.



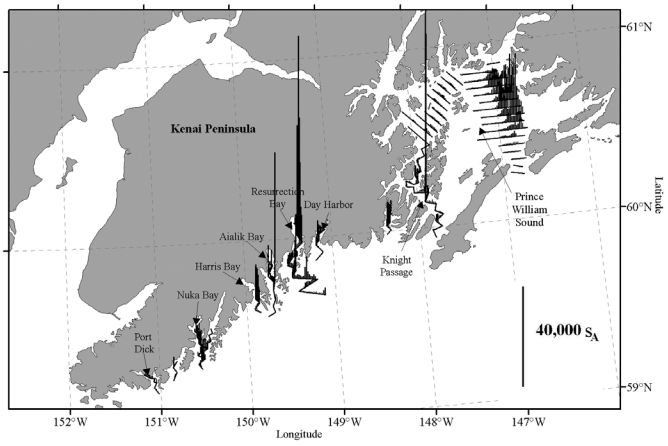


Figure 2 (top). Acoustic backscattering (S_A) attributed primarily to walleye pollock (vertical lines) along transects during the March 2010 acoustic-trawl surveys of Marmot Bay, Shelikof Strait and the Gulf of Alaska shelf break from Barnabus Trough to Chirikof Island. Figure 3 (above). Acoustic backscattering (S_A) attributed primarily to walleye pollock (vertical lines) along transects during the March 2010 acoustic-trawl surveys of the Gulf of Alaska along the southern edge of the Kenai Peninsula and throughout Prince William Sound.

The workshop also presented an opportunity for strategic-planning discussions with OCS leaders about future joint projects. Detailed planning for "piggyback" testing of the acoustic positioning system on the NOAA ship *Fairweather* during a hydrographic survey this summer in Washington's Olympic Coast National Marine Sanctuary (OCNMS) also took place, involving the HRG, the ship's command, OCS principals, and the OCNMS chief scientist for that cruise.

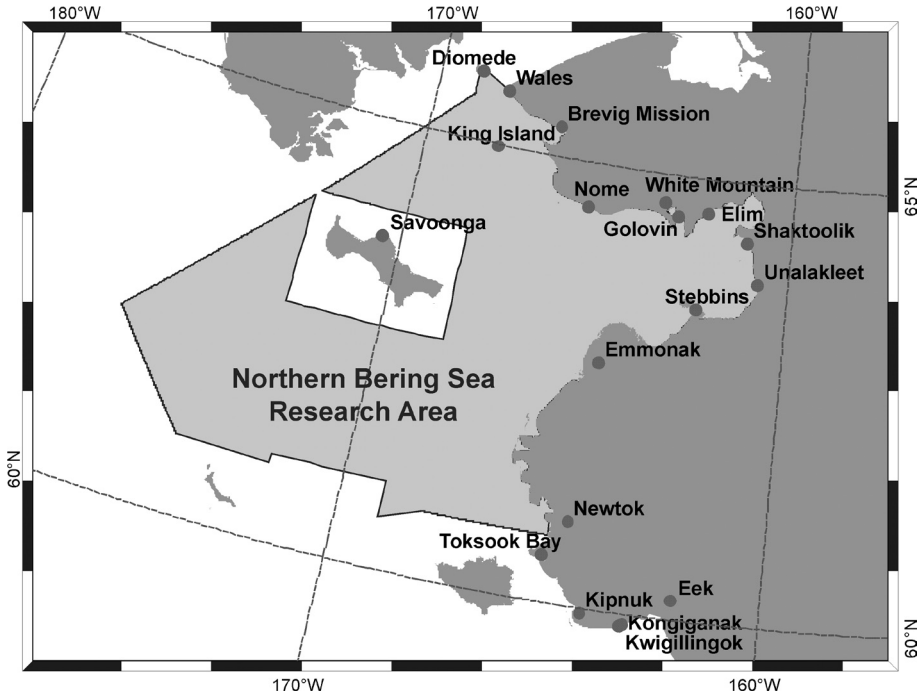
By Bob McConnaughey

Northern Bering Sea community members participating in the NBSRA Community and Subsistence Workshop asked for continued dialogue with resource management and resource research agencies concerning the NBSRA scientific research plan.

Northern Bering Sea Research Area (NBSRA) Research Planning - Community and Subsistence Workshop

The AFSC RACE Division continues to spearhead the development of the scientific research plan for the Northern Bering Sea Research Area (NBSRA) to study the effects of bottom trawling on benthic species and habitat. Currently, development of the plan focuses on gathering existing knowledge—local, traditional, and scientific—of the area to inform planning. The AFSC hosted the Community and Subsistence Workshop at the Anchorage Chamber of Commerce in Anchorage, Alaska, on 24-25 February 2010. The objectives of the workshop were to communicate the intent of the NBSRA to western Alaska communities, solicit their input for the research plan, learn from their knowledge, and register their concerns. The subsistence and culture of the communities are closely tied to the environment and animals of the northern Bering Sea. Their knowledge of the area is of great value to science and resource management, while management actions and policies in the area may greatly impact their lives.

For the workshop, it was important to identify and invite key representatives from the diverse NBS communities. These were to include not only community leaders, but elders and hunters who could inform on subsistence activities and conservation needs. The NMFS Alaska Regional Office (AKR) and the North Pacific Research Board (NPRB) provided funding to the Rural Alaska Community Action Program, Inc. (RurAL CAP) to facilitate the workshop and to support travel for the invitees identified by RurAL CAP. The staff of the North Pacific Fishery Management Council (NPFMC) and the AKR were instrumental in widely advertising the workshop to all NBS communities and in organizing the workshop.



The Northern Bering Sea communities represented at the NBSRA Community and Subsistence Workshop.

Over 20 communities along the eastern Bering Sea coast from Kuskokwim Bay to the Bering Straits were represented at the workshop. Also in attendance were representatives from conservation groups, the trawl fishing industry, and the Anchorage community. Pat Livingston (NPFMC Scientific and Statistical Committee Chair and AFSC Resource Ecology and Fisheries Management (REFM) Division Director) opened the workshop by emphasizing the objectives of the workshop and introducing the attending agency staff. Staff from the AKR, AFSC, and the U.S. Fish and Wildlife Service proceeded to present information on the policies, research planning, subsistence species, and proposed research in the NBSRA. The Bering Sea Elders Advisory Group presented maps of some critical areas of subsistence usage in the Nunivak Island, Etolin Strait, and Kuskokwim Bay region. Community participants raised questions and commented vigorously on each presentation. Ample discussion flowed on a broad array of issues pertaining to their subsistence and socioeconomic interests.

Livingston closed the workshop with a summary of main concerns raised by the communities to be considered in the research planning and management of the NBSRA.

The resounding request from the communities was for continual, productive dialogue with the resource management and research agencies in the NBS. The AFSC recognizes that the experiences and traditions of the subsistence communities in the NBS are integral to understanding the ecosystem and, in themselves, valuable cultural assets, and that effort must be made for better relations and communications with the communities. More information on the workshop is available on the NPFMC website at http://www.fakr.noaa.gov/npfmc/current_issues/ecosystem/NBSRA.htm.

By Cynthia Yeung

KODIAK LABORATORY

Kodiak Laboratory Launches Ocean Science Discovery Lab

"To advance environmental literacy and promote a diverse workforce in ocean, coastal, Great Lakes, weather, and climate sciences, encouraging stewardship and increasing informed decision making for the Nation." This is the mission statement in NOAA's outreach and education strategic plan as mandated in the America COMPETES Act in part to enhance public awareness, understanding, and stewardship of the oceans.

The Kodiak Laboratory at the Kodiak Fisheries Research Center (KFRC) in Kodiak, Alaska, is embracing NOAA's outreach and education mission with a new initiative called the Kodiak Ocean Science Discovery Lab (OSDL). In close cooperation with the Kodiak Island Borough School District (KIBSD), the OSDL program was launched in 2009 to improve science education by bringing place-based, hands-on learning from the science community to the classroom. Dr. Switgard Duesterloh, an AFSC contractor and KIBSD part-time employee, is leading the OSDL efforts.

Of particular significance in the OSDL program is the diverse cross section of students that the program will influence. Kodiak is home to one of the largest commercial fishing ports in the United States and as such supports a diverse community of harvesters and processors with origins throughout the world. Kodiak is home to the largest U.S. Coast Guard base in the country, supported by personnel whose families represent all corners of the Nation. Kodiak Island also boasts a growing tourist industry bringing interest in the marine environment from all parts of the world as exemplified by the more than 12,000 visitors to the aquarium at the KFRC in 2009. Therefore, the OSDL has an opportunity to bring ocean literacy and a fisheries focus to a broad, diverse student community.

PROGRAM COMPONENTS

THE ELEMENTARY PROGRAM – Kodiak students in grades 3-5 are introduced to marine plants and animals during field trips to the OSDL, the KFRC aquarium, and the KFRC Seawater Facility. In close cooperation with KIBSD teachers, OSDL science lessons are designed to strengthen the grade level curriculum by integrating and reinforcing required learning contents with exciting hands-on learning.

The third and fourth grade curriculum addresses the Food Web. Kodiak students learn about trophic levels at various stations set up in the OSDL. They learn about sunlight as the energy source for all plant life, take a peek at diatom cells under a microscope, and sort through local seaweeds. At a zooplankton station, they use stereomicroscopes to look at fixed and live plankton samples and study how a plankton splitter works. At the invertebrate and fish station, they observe and touch filter feeders, grazers, and predators of the local intertidal environment and handle Tanner and king crabs. University of Alaska faculty participate in the OSDL curriculum by explaining how sea lions, seals, and whales feed, and provide skulls, teeth, and baleen for the students to explore. To summarize the unit, students are given photographs of local marine life and are asked to assemble food chains, then to find links between food chains to demonstrate the web of life.

Fifth grade students are introduced to scientific experimentation. Classes are divided into small groups, and each group receives two sea stars. Students learn about the biology of sea stars, radial symmetry, and the properties of echinoderms. After instruction on performing righting experiments with their sea stars, students learn to make predictions and are asked to predict which sea star

Top: Fourth grade Kodiak students look at diatoms under a microscope and learn about their function in the ecosystem. Above: Kodiak students learn about coastal organisms in the Kodiak Fisheries Research Center touch tank maintained by AFSC staff.

will turn over the fastest according to species and size. Students then take radial measurements, record their data, and measure the time their sea stars take to right themselves. From their measurements, students calculate averages. Data from all groups are compiled in a data table and charted in an XY-scatterplot. The unit concludes with a discussion of the results, the data range, and factors that might influence the outcome of the experiment.

After concentrated learning in the OSDL, classes often visit the KFRC aquarium and touch tank where students are provided hands-on learning about local marine organisms such as sea anemones, fishes, crabs, snails, sea urchins, and sea cucumbers. They are also given tours of the research facilities where they learn about ongoing NOAA Fisheries research and sometimes shake a tentacle with the KFRC pet octopus.

In its first year, the OSDL program provided lessons in marine science to over 450 elementary students. With them, an estimated 100 teachers and parents participated. Seventeen local scientists and naturalists from NMFS, the Kodiak Island Borough, the Alaska Department of Fish and Game, the University of Alaska, and the community at large volunteered their time and expertise for student outreach at the various activities in the OSDL.

THE MIDDLE SCHOOL PROGRAM – Development of a middle school program is a high priority for the 2010-11 school year. Suggestions include alteration of existing science curricula to include scheduled visits from scientists to the classroom, with a long-term vision of a science week where all eighth grade students visit the OSDL on three consecutive days to design, conduct, and summarize their own scientific experiments, with the opportunity for an after-school marine science club, a summer camp, and marine science summer courses.

THE HIGH SCHOOL PROGRAM – The OSDL supports Kodiak High School by providing interaction with scientists at the OSDL for students enrolled in the oceanography class and those participating in the annual Ocean Science Bowl. In addition to literature research, technical writing, public presentation, and textbook content the class will study more advanced scientific topics with local scientists such as sampling, sample processing, and experimentation.

THE MARINE INSPIRED ART PROGRAM – Reaching out to the community, the OSDL in cooperation with the Kodiak Arts Council offered three combined science lectures and art workshops in 2009. The activities started with a 15-minute lecture about the biology and ecology of a featured marine animal and an opportunity for participants to see and touch the animal. Participants were then invited to a workshop where they created the featured animal from a prepared set of materials. Marine Inspired Art workshops were well accepted in the community by participants from ages 1 to 65.

By Switgard Duesterloh and Robert Foy

Resource Ecology & Fisheries Management (REFM) Division

RESOURCE ECOLOGY & ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

During the first quarter of 2010, the majority of fish stomachs analyzed by the Resource Ecology and Ecosystem Modeling (REEM) Program staff focused on very detailed identification and enumeration of the prey taxa. This information is being used to satisfy requirements of an essential fish habitat (EFH) project and a project dealing with flatfish prey selectivity in the eastern Bering Sea. This information is also a critical component of a Bering Sea Integrated Ecosystem Research Program (BSIERP) project to examine the functional feeding responses to predator, prey, and environmental conditions. Stomach samples were analyzed from eight predator species from the eastern Bering Sea (n = 1,660) and four predator species from the Gulf of Alaska and Aleutian Islands regions (n = 192). Laboratory personnel dried 665 tissue samples in preparation for stable isotope analysis. Fisheries observers returned 71 stomach samples from the eastern Bering Sea. In total, 5,426 records were added to the REEM food habits database.

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

Ecosystem Modeling

Two full-day workshops with field biologists and modelers were held at the AFSC in early and mid-February as part of the development of the BSIERP FEAST (Forage/Euphausiid Abundance in Space and Time) model. Workshop themes revolved around fish bioenergetics, growth, reproduction, and movement. The purpose of the workshops was to get direct feedback from BSIERP field researchers to fill in gaps and improve model parameters and processes using current published and unpublished results from studies conducted by BSIERP and AFSC researchers. A total of 20-30 participants attended each of the workshops with some attendees joining remotely from California; Auke Bay Laboratories; and Corvallis, Oregon. The workshops provided an amicable forum for discussions and served as a starting point for new collaborations. Multiple meetings among individual researchers and teams have followed and will continue throughout model development.

By Ivonne Ortiz and Kerim Aydin

REEM Staff Attend the Pacific Seabird Group Annual Meeting

The Pacific Seabird Group (PSG) annual meeting, held in Long Beach, California, 17-21 February, was attended by REEM Program scientists Shannon Fitzgerald and Stephani Zador. Preconference meetings included the PSG food habits/diet subcommittee where comments were well received regarding the food habits component of the AFSC seabird necropsy program. The North Pacific Albatross Working Group also attended. Fitzgerald and Zador presented "Vessel-specific seabird bycatch in Alaska demersal longline groundfish fisheries, 2004-2007" and "Seabird attraction to fishing trawlers relative to discard type," respectively. A poster was also provided titled "A pilot project on seabird interactions with paravane gear on an Alaskan groundfish trawl catcher processor." More information on the meeting can be obtained at the PSG website at http://www.pacificseabirdgroup.org/ under the heading Annual Meeting.

By Shannon Fitzgerald

Ecosystem Indicators

REEM Program researchers, Kerim Aydin, Sarah Gaichas, and Stephani Zador, attended a workshop on ecological and economic indicators hosted by the North Pacific Fishery Management Council's (NPFMC) Science and Statistical Committee (SSC) in Portland, Oregon, on 10 February.

They presented an overview of the current Ecosystem Considerations appendix to the Stock Assessment and Fisheries Evaluation (SAFE) report and reviewed the comments on the appendix provided by the SSC. In general, the comments focused on the need to provide more synthetic statements about the state of Alaskan marine ecosystems, encourage further interactions between stock assessment authors and ecosystem scientists, and streamline the use of indicators in environmental assessment. The goal of the presentation was to address these comments and seek SSC feedback on proposed methods to improve the utility of the appendix.

It was proposed that the appendix be reorganized into three sections with varying levels of detail: a highly focused 3-5 page executive summary suitable for a broad audience, a 20 page synthesis/environmental assessment, and a large section merging individual contributions on environmental status and management indices. Opportunities for further collaboration between stock assessment authors and ecosystem scientists were discussed during the workshop and during a later presentation to the stock assessment authors. The SSC discussed the use of ecosystem synthesis teams to decide on indices to summarize for the eastern Bering Sea, Aleutian Islands, and Gulf of Alaska ecosystems. The existing Aleutian Islands Fishery Ecosystem Plan team might act as a model for eastern Bering Sea and Gulf of Alaska ecosystem synthesis teams, although a formal Council process for team formation may not be necessary. The SSC supported the overall proposed new organization of the appendix and suggested that the presentation of the Ecosystem Considerations appendix come at the start of the NPFMC's Groundfish Plan Team and Council meetings, before the presentation of the individual species' stock assessments, so that assessments and management actions could be evaluated within the context of the state of the Alaska marine ecosystems.

By Stephani Zador, Sarah Gaichas, and Kerim Aydin

FEAST Model Parameterization

Relationships between walleye pollock and their zooplankton prey are being investigated to support parameterization of the FEAST model for BSIERP. One source of zooplankton community data is the bongo net tows conducted during the AFSC's bottom trawl survey of the eastern Bering Sea continental shelf. Walleye pollock stomach samples were targeted for collection at nearly the same location and time during 2006, 2007, and 2008. The dedication of the AFSC survey personnel and the captain and crew of the chartered fishing vessel *Arcturus* made collection of these samples possible.

Generally, the bongo net captured mostly copepods, some chaetognaths, and fewer euphausiids and larvaceans. As is typical in the pollock diet, copepods tended to be a greater percentage of the consumed zooplankton along the outer edge of the continental shelf, and copepods were generally more important in the diet of smaller pollock (fork length (FL) ≤ 45 cm) than larger pollock (≥ 46 cm FL). Our preliminary results indicate that for smaller pollock, when copepods are eaten at the sampling station, there may be a weak positive relationship between number of copepods eaten per fish and local copepod density in the water (Fig. 1). At stations where euphausiids occur in the Bongo net catch, the average number of euphausiids eaten by larger pollock may have a weak negative relationship to euphausiid density in the water (Fig. 2). In other words, when more euphausiids are found in pollock stomachs, there appears to be fewer in the water. This may suggest that pollock can rapidly graze down the local abundance of euphausiids. As more data from sampled stations become available, we will be able to refine our analyses to tighter subsets of stations (geographically), of pollock (narrower size categories), and of consumed zooplankton (digestion state).

By Troy Buckley, Todd TenBrink, Jeffrey Napp, and Kerim Aydin

CAMEO Workshop on Predator-Prey Interactions

Stephani Zador and Sarah Gaichas participated in a workshop on the role of predator-prey interactions in marine ecosystem organization at Oregon State University (OSU) in Corvallis, 16-18 March. The workshop was part of a project co-organized by Kerim Aydin and Kevin Bailey (AFSC), Lorenzo Ciannelli (OSU), and Kung-Sik Chan (University of Iowa) and funded under the Comparative Analysis of Marine Ecosystem Organization (CAMEO) program administered jointly by NOAA and the National Science Foundation. Over 30 scientists from U.S. and European universities and agencies attended.

The primary purpose of the workshop was to examine the state-of-the-art in methods for scaling up from local observations of predator prey interactions to aggregative, functional, and numerical population and community responses at multiple scales, including regional resource management scales. Presentations included reviews of numerical and functional response representations to date, methods for scaling functional responses and spatial ecology of predator prey interactions, predator prey models used in fisheries and other applications, new statistical methods for cross-scale analyses, and management implications of

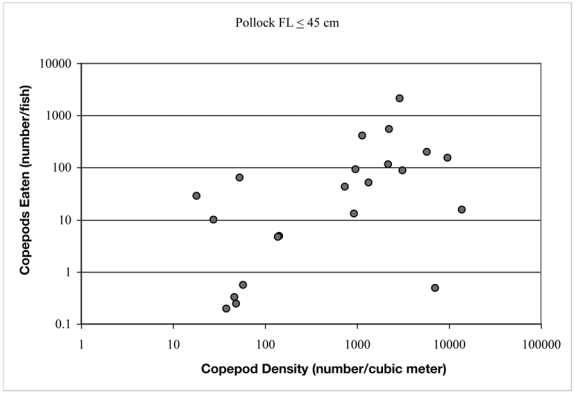


Figure 1. The average number of copepods eaten per fish by smaller pollock plotted against the copepod density found at that station.

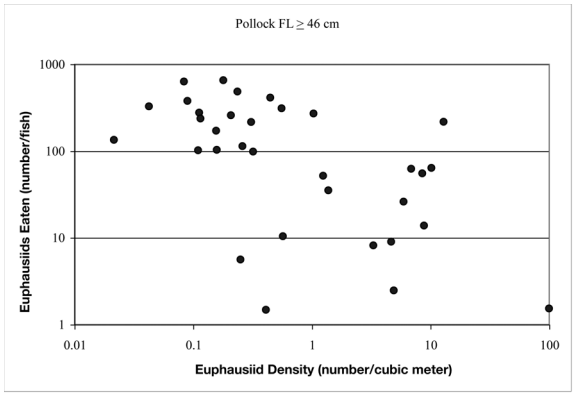


Figure 2. The average number of euphausiids eaten per fish by larger pollock plotted against the euphausiid density found at that station.

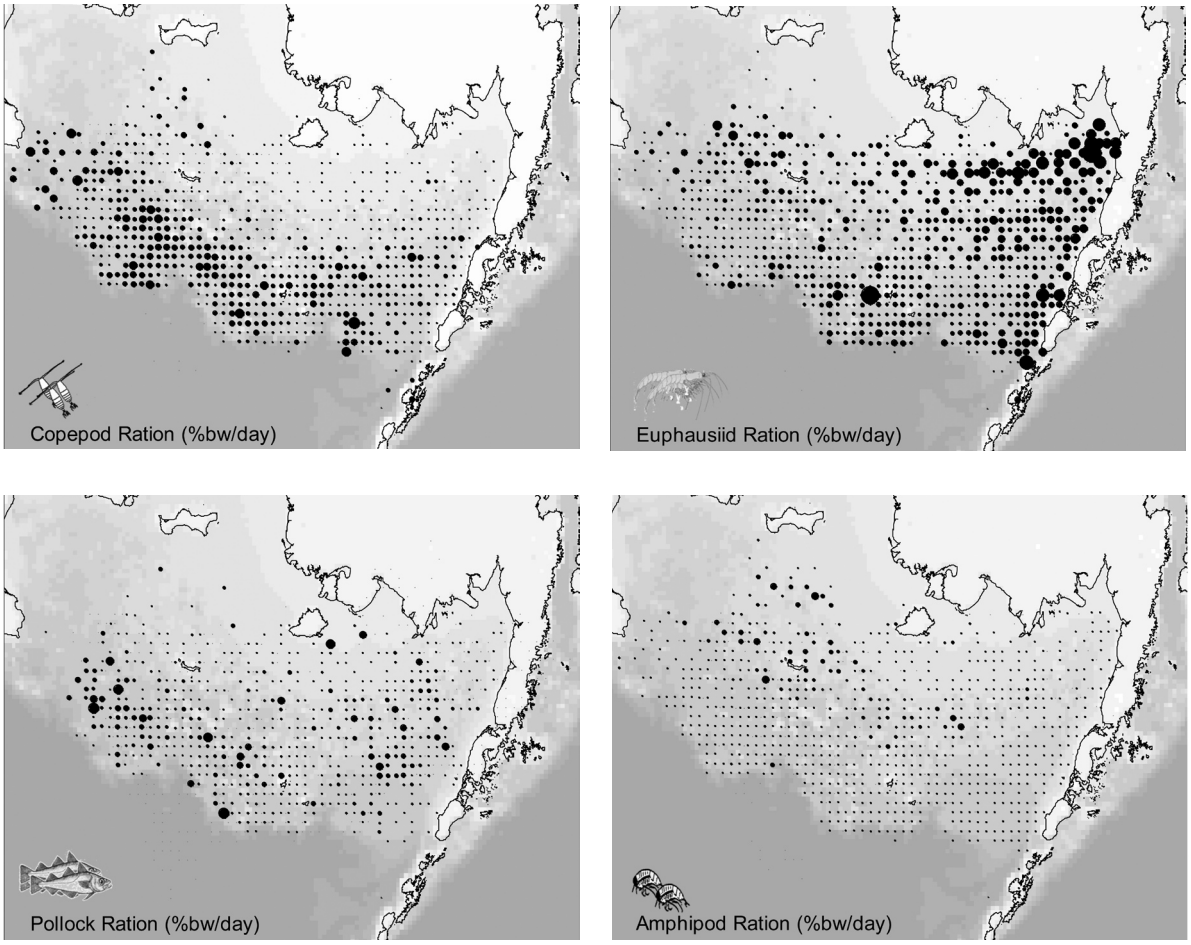


Figure 3. The relative ration of walleye pollock as measured from prey weights in pollock stomach contents, for four major prey types from May-September, combining all years 1982-2008.

predator prey interactions. Stephani Zador presented a plenary presentation on functional and numerical response observations for seabirds. Sarah Gaichas led a breakout discussion group on models and networks. Discussion groups worked on the outline for a review paper summarizing the main findings of the workshop, which will be submitted to a peer reviewed journal later this year.

By Sarah Gaichas and Stephani Zador

REEM Program Represented at the Alaska Marine Science Symposium

Kerim Aydin attended the North Pacific Research Board's Alaska Marine Science Symposium, 18-22 January in Anchorage, Alaska, where he presented a talk titled "A web for all seasons: an analysis of 30 years of seasonal and geographic variability in marine food webs through fish food habits and stable isotope analyses." The talk summarized a substantial portion of the data collected by the REEM Program since 1982 and focused on the biogeography of predator feeding in the Bering Sea. Highlighted were the diets of walleye pollock, which consume up to 60% of the secondary production in the Bering Sea annually and thus are a keystone predator. The patterns of their prey over time show oceanic domains, for example, with copepods dominating pollock diets on the outer Bering Sea shelf, euphausiids dominating the inner shelf and southern portion of the Bering Sea, and amphipods being a primary prey associated with the Bering Sea Cold Pool (Fig. 3).

By Kerim Aydin

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Bering Sea-Aleutian Islands (BSAI) Crab Annual Catch Limits and Rebuilding Analyses

Economic and Social Sciences Research (ESSR) Program staff have collaborated extensively with members of the Bering Sea Aleutian Islands Crab Plan Team to develop and analyze alternatives for implementing the annual catch limits required under the Magnuson Stevens Fishery Conservation and Management Act reauthorization and to develop rebuilding plans for eastern Bering Sea snow and Tanner crab stocks, and Pribilof Island blue king crab. Extending earlier work performed for the Council, ESSR economist Mike Dalton developed time series vector autoregression price forecasting models for king and snow crab. Crab Plan Team member and ESSR economist Brian Garber-Yonts worked with stock assessment analysts to integrate simulations of crab population and directed catch forecasts with price forecasts to simulate economic outcomes and illustrate the tradeoffs between reducing the risk of overfishing and the attendant cost in foregone revenue under annual catch limits and rebuilding alternatives. Economic analyses of revenue implications have been produced for each of nine BSAI crab stocks regulated under the Council's Crab

Fishery Management Plans and incorporated into the preliminary Environmental Assessment and Regulatory Impact Review/ Initial Regulatory Flexibility documents for SSC and Council review at the April 2010 meeting in Anchorage. Methods for analysis were presented to the SSC in February 2010, and the initial review documents will be formally released to the Council for the June meeting, with final drafts to be issued for the October Council meeting.

By Brian Garber-Yonts

Estimating Statewide and Regional Economic Impacts of Saltwater Sportfishing in Alaska

ESSR researchers Dan Lew and Chang Seung recently conducted a study in which the economic impacts of non-resident saltwater sportfishing in Southeast Alaska were calculated under a variety of alternative sport fish harvest bag limit changes for three of the primary species targeted in Alaska recreational saltwater fisheries: Pacific halibut, king (Chinook) salmon, and silver (coho) salmon. To this end, they combined a stated preference choice experiment (SPCE) model with a state-level computable general equilibrium (CGE) model of Alaska. The results of this analysis were presented at the 2010 Western Regional Science Association conference, and a paper describing this work is forthcoming in the *North American Journal of Fisheries Management*. The findings suggest that the economic impacts resulting from changes in bag limits calculated from the CGE model are smaller than those from a social accounting matrix (SAM) model and that much of the economic impact from an increase in the expenditures leaks out of the state due to the state's heavy dependence on imports of goods and services from the rest of the United States.

Given that the CGE model used in this study is a state-level model, it is not surprising that the economic impacts estimated in this study are modest relative to the overall size of the Alaska state economy. However, these results may understate the impact on coastal regions, as they are likely to be geographically concentrated on the coastal communities that are most directly involved with these economic activities. To investigate these regional-level impacts, these researchers plan to conduct an analysis using the SPCE model results and a CGE model for Southeast Alaska to estimate the localized economic impacts of various saltwater sportfishing policies.

By Dan Lew and Chang Seung

Study to Gather the Oral History of Oregon Residents in Alaska's Historical Commercial Fishing Boom Times

National Standard Eight of the Magnuson Stevens Fishery Conservation and Management Act states that "conservation and management measures shall, consistent with the conservation requirements of this Act (including the prevention of overfishing rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to (A) provide for the sustained participation of such communities, and (B) to the extent practicable, minimize adverse economic impacts on such communities. "In order to meet the requirements of National Standard Eight, it is important that we understand the past participation of communities to "provide for the sustained participation" of these communities. Our study will focus on those in the harvest sector including boat owners, captains, and crew members.

The study will gather oral histories of Oregon fishermen who began their fishing careers in Alaska during the commercial fishing boom of the 1980s. Recent field work from Oregon State University in Oregon fishing communities revealed that many current Oregon commercial fishermen got their start fishing in Alaska during the boom days of the 1980s. These fishermen in many cases were able to purchase their fishing vessels using the money earned fishing in Alaska. Many of these Oregon fishermen are now nearing retirement age and have spent the bulk of their fishing careers fishing locally in Oregon, but some are still involved seasonally in Alaska fishing.

This project will collect oral histories from these fishermen to 1) document this important time in Alaska fishing history and document Oregon residents' involvement in this historic multiregional connection; and 2) examine the social linkages between the Northwest and North Pacific fisheries to analyze the extent to which the North Pacific fisheries provided a means for West Coast commercial fishermen to enter the fishing industry in both the past and present.

Unstructured interviews will be conducted in Newport, Oregon, and other Oregon communities suggested by contacts and participants. The interview phase of this project will begin in April and will continue throughout the summer. This project is supported by the NOAA Preserve America Initiative, part of Preserve America, a federal initiative aimed at preserving, protecting, and promoting our nation's rich heritage. This project is also supported by NMFS.

By Christina Package

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

SSMA Research Presented at the Alaska Marine Science Symposium

Status of Stocks and Multispecies Assessment (SSMA) Program researchers Libby Logerwell and Steve Barbeaux and Lowell Fritz (National Marine Mammal Laboratory) presented a poster at the 2010 Alaska Marine Science Symposium titled, "Using cooperative acoustic surveys to manage small-scale fisheries in sensitive habitat: The relationships between distribution of Steller sea lions, diet composition, prey biomass distribution and oceanographic properties." The goal of this research is to investigate whether cooperative biomass surveys are an effective way to manage fisheries at local scales important to predators such as Steller sea lions. The long-term vision is that one or more commercial fishing vessels conducts hydroacoustic surveys in specific areas of Steller sea lion critical habitat prior to commercial fishing beginning in these areas. Biomass estimates from these surveys would then be used to set a quota for the area surveyed that does not jeopardize the foraging success of Steller sea lions in the area. To design an effective cooperative survey, one needs to know whether the data collected by commercial vessels are of sufficiently high quality and resolution, and sufficiently low variability to assess biomass at local scales. One also needs to know where the fishery would be expected to operate and where Steller sea lions prey upon pollock. Finally, information on the physical oceanographic processes that drive pollock distributions is important for building conceptual models of the interactions between environment, fishing, prey, and predators. To address these information needs, replicate winter acoustic surveys of pollock were conducted in the central Aleutians from a NOAA research vessel and a commercial vessel equipped with a scientific quality ES60 echosounder.

To assess the relative importance of haulouts near pollock spawning areas and near fished areas, data were collected on sea lion distribution and diet. Physical and biological oceanographic data were collected to compare water column properties in areas of high and low pollock biomass.

The study design and data analyses were directed by the following conceptual model: geographic patterns in Steller sea lion haulout and diet composition are directly related to pollock distribution and abundance and indirectly related to water depth, water column structure, and satellite-derived estimates of chlorophyll. The diet composition of sea lions showed a response to spatial variability in pollock abundance (a functional response), however, the distribution of sea lion abundance did not (a numerical response). The distribution of sea lions may primarily reflect the distribution of Atka mackerel. Atka mackerel are a dominant prey item for Steller sea lions during all seasons, whereas it appears that pollock (and Pacific cod, along with a suite of demersal species) are important prey primarily in the winter. This suggests that sea lion diets respond to small-scale, short-term distribution of prey. Seasonal diet changes reflect differences in availability due to seasonal differences in spawning and aggregating of various prey species.

To assess the indirect, environmental effects on sea lions, a suite of oceanographic properties were examined as indicators of ocean production. None showed more than a suggestive relationship with the distribution and abundance of pollock biomass, and thus the availability of Steller sea lion prey. However, the processes underlying these oceanographic indicators, such as mixing cold, nutrient rich waters to the surface, may only be relevant during the spring and summer when light levels are sufficient for chlorophyll growth and subsequent food chain productivity to take place. If oceanographic processes are important for driving the distribution and abundance of pollock in the Aleutian Islands during winter, they were not well represented by the variables examined and a new conceptual model needs to be developed that takes into account whatever other processes are important during this season.

By Libby Logerwell

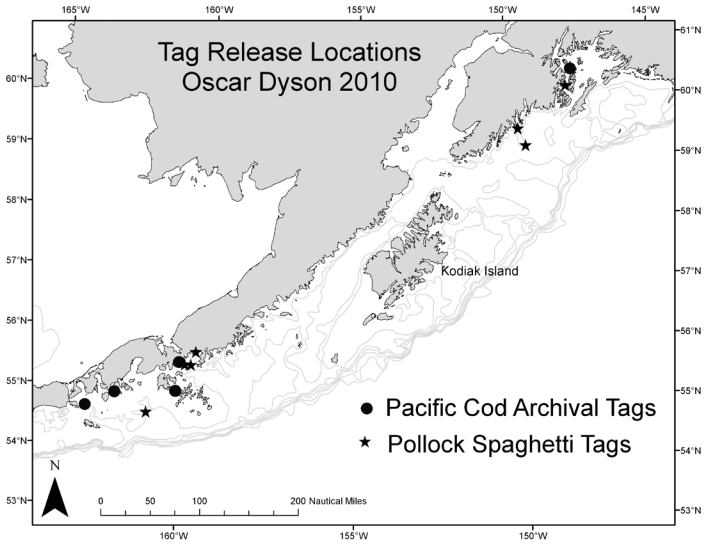


Figure 4. Tag release locations of Pacific cod and walleye pollock during the 2010 MACE Gulf of Alaska cruise aboard the NOAA ship *Oscar Dyson* in the Shumagin Islands and Prince William Sound area.

Release of Pacific Cod with Geolocating Archival Tags in the Gulf of Alaska

The SSMA Fisheries Interaction Team and other SSMA staff are conducting research to determine the utility of electronic archival tags for studying movement in Pacific cod. In collaboration with the AFSC's Midwater Assessment and Conservation Engineering (MACE) program, Pacific cod were successfully tagged and released aboard the NOAA ship *Oscar Dyson* during a hydroacoustic survey conducted 20 February – 19 March in the Shumagin Island and Prince William Sound areas.

Pacific cod are an important ecosystem component in the Gulf of Alaska and Bering Sea and support a lucrative commercial fishery. Existing data suggest that Pacific cod migrate annually from summer feeding grounds to winter spawning grounds where they form dense aggregations. Temporal and spatial aspects of this yearly movement pattern are poorly understood.

Archival electronic tags containing environmental sensors (e.g., temperature and depth) can be attached to fish to investigate individual behaviors. These tags are usually recovered through commercial fisheries. Tags that collect light data can be used to estimate the geographic position of fish by using the timing of sunrise, sunset, and local noon to estimate latitude and longitude. Light-sensing tags have been used to predict the geographic location of fish in Alaska waters, but the spatial resolution of the data can vary at different latitudes and with different tag types. A new generation of archival tags (Lotek Wireless Inc., LAT series) has recently been developed and promises to increase the accuracy and precision of geolocation estimates. In addition, these tags are small enough to be implanted in medium-sized fish (40-60 cm) and are therefore a promising tool to record the large-scale movement of many commercially exploited species in Alaska.

The Lotek LAT tags have light, depth, and temperature sensors and store data from these sensors at user-determined time intervals. A processor on the tag produces a daily estimate of position that includes an estimate of the associated error. These tags were tested on fixed moorings in the field in 2009 and also tested on captive Pacific cod in collaboration with the AFSC's Auke Bay Laboratories

Figure 5. Lotek Archival tags implanted into body cavity of a Pacific cod. Photo by Susanne McDermott.

Figure 6. AFSC scientist Darin Jones ready to release a tagged Pacific cod. Photo by Susanne McDermott.

and Kingfisher Marine Research in Juneau, Alaska.

The AFSC recently purchased LAT tags for implantation in wild Pacific cod. The annual MACE survey in the Gulf of Alaska provided a convenient platform for releasing these tags (Fig. 4). Pacific cod were captured during survey trawls. Live fish were immediately transferred to seawater tanks and monitored for survival. Of 55 fish placed in the tanks, 33 survived, resulting in a 60% survival rate. Mortality was most likely caused by barotrauma (damage resulting from an inflated swimbladder).

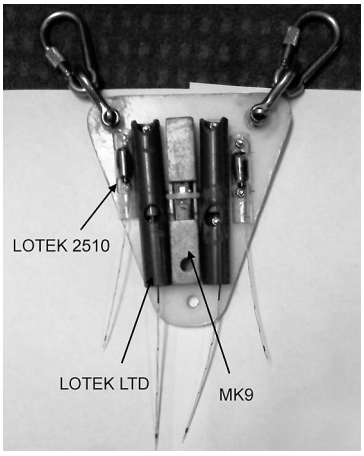


Figure 7. Configuration of the light meter sled.

Twenty-two of the survivors received archival tags, which were implanted into the abdominal cavity with the light stalk protruding from the fish (Figs. 5 and 6). Only one fish died after the tag was implanted, most likely from handling trauma during capture.

In addition to tagging Pacific cod, walleye pollock were tagged with conventional T-bar spaghetti tags and released (Fig. 4). This work served as a pilot project to test the feasibility of tagging pollock caught with the MACE survey trawl gear. Of the 84 pollock captured, 65 survived (resulting in a 78% survival rate) and were tagged. This study demonstrated that pollock had good survival after capture in small survey trawls with knotless 0.5 inch mesh liners. Tagging of pollock during the MACE surveys might therefore prove to be a feasible undertaking in the future.

In a third aspect of the study, several of the Lotek tags were deployed on the trawl gear with two other types of light-sensing tags (Wildlife Computers MK9 and Lotek LTD tags) to compare the performance of the light sensors at depth and under different conditions of water clarity (Fig. 7). Similar comparisons have been conducted in the past, but those tests took place in the tropical ocean, which is typically much clearer than high-latitude waters. The results of this comparison will be used to understand the utility of different tags in Alaska and may guide development of tags designed specifically for northern regions.

The study described here is part of ongoing efforts by the AFSC to understand large-scale movements of Pacific cod and other species in Alaska waters. The successful tagging of walleye pollock on this cruise suggests we may be able to apply similar techniques to the most abundant commercial species in Alaska. The technological development of electronic tags will continue to improve, increasing our ability to glean information from individual tagged fish.

By Susanne McDermott and Olav Ormseth

AGE & GROWTH PROGRAM

Ocean Sciences Meeting

At the 2010 Ocean Sciences Meeting in Portland, Oregon, (22-26 February 2010), Thomas Helser of the Age and Growth (A&G) Program and Bryan Black of Oregon State University convened a session entitled "Growth Increments and the Environment: Multidecadal Perspectives on Climate and Ecology in Marine Systems." Papers presented by A&G Program staff included "Climate-driven synchrony in otolith growth-increment chronologies for three Bering Sea flatfish species" by Beth Matta, Byran Black, and Tom Wilderbuer and "Validation of crossdated age estimates with bomb-produced radiocarbon for Pacific geoduck (*Panopea abrupta*)" by Craig Kastelle, Thomas Helser, and Bryan Black.

By Thomas Helser

Age and Growth Production Numbers

Estimated production figures for 1 January – 31 March 2010. Total production figures were 9,346 with 1,965 test ages and 91 examined and determined to be unageable.

Species	Specimens Aged
Arrowtooth flounder	792
Atka mackerel	105
Dusky rockfish	606
Giant grenadier	784
Northern rock sole	1,305
Northern rockfish	498
Pacific cod	1,413
Pacific ocean perch	581
Rougheye rockfish	150
Southern rock sole	509
Walleye pollock	1,845
Yellowfin sole	758

By Jon Short