Auke Bay Laboratories (ABL)

OFFICE OF THE LABORATORY DIRECTOR

Auke Bay Climatology/Meteorology, Summary for 2008

Meteorological observations and their summarization in climatological studies are critical data for fisheries oceanographers and ecologists. Solar radiation, temperatures, precipitation, and their variations drive ocean currents, circulation, and photosynthetic processes which in turn influence the fluctuations of biological populations important to fisheries. Consequently, daily weather observations and the maintenance of these records are important to NOAA's mission and its several components: the National Weather Service (NWS), the National Marine Fisheries Service (NMFS), and National Ocean Service (NOS).

Daily weather observations at the Auke Bay Marine Station were initiated in February 1963 as part of the National Weather Service Cooperative Observer Program. The observations include the daily maximum and minimum air temperature, daily precipitation, daily snowfall, and snow on the ground. Sea surface temperatures (SST) have been included since 1975. Daily observations are taken at about 16:30 hours.

The calendar year 2008 was notable for being a wet, cold year. This was particularly evident in the SST observed at the Auke Bay Marine Station float.

The annual average SST since 1975 has been 8.17°C, the 2008 average SST was 7.38°C, the second lowest annual SST in the time series (Fig. 1). With few exceptions, the daily SST remained well below average throughout 2008 (Fig. 2). July through mid-September was unusually cold. Although it is too early to see the results of such a year on our fisheries, these cold winter-spring-summers have been associated with poor recruitment to salmon, halibut, sablefish, and rockfish stocks in Southeast Alaska.

The year 2008 was a typical wet year, having 69.11 inches (175.54 cm) of precipitation compared to the average of 60.64 inches (154.03 cm). Maximum recorded precipitation was 84.80 inches (215.39 cm) in 1991.The nearly continuous cloud cover, especially through the summer, left the impression of an unusually wet year. This was especially so for gardeners and berry pick-

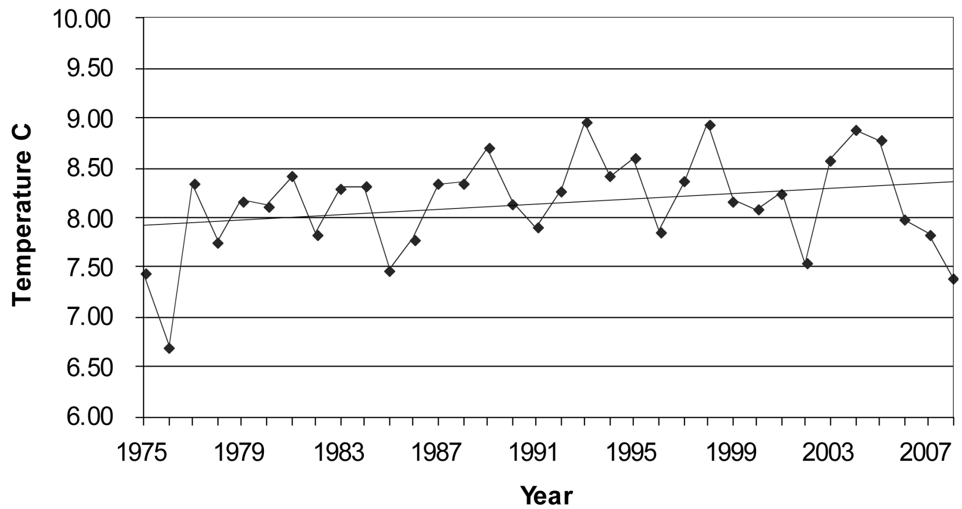


Figure 1. Annual average Auke Bay, Alaska, sea surface temperature: 1975 through 2008.

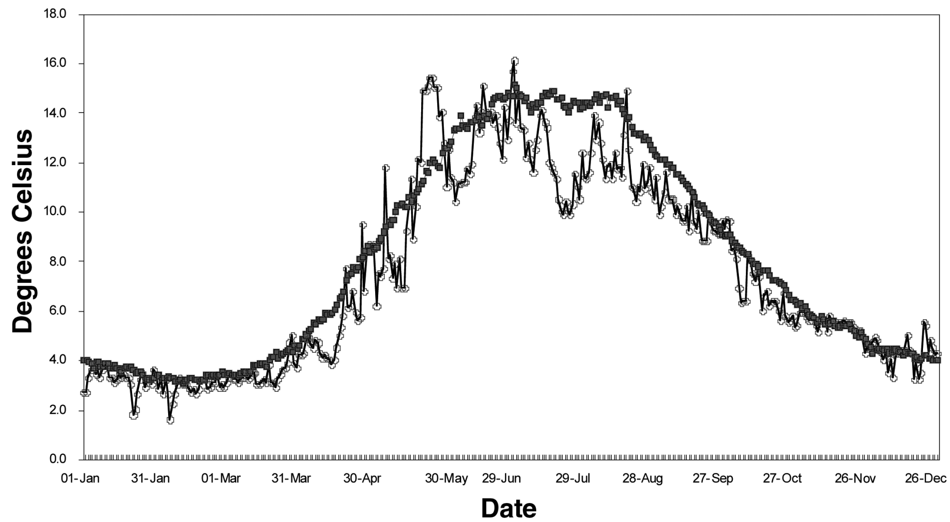


Figure 2. Auke Bay, Alaska sea surface temperatures: 2008 versus mean

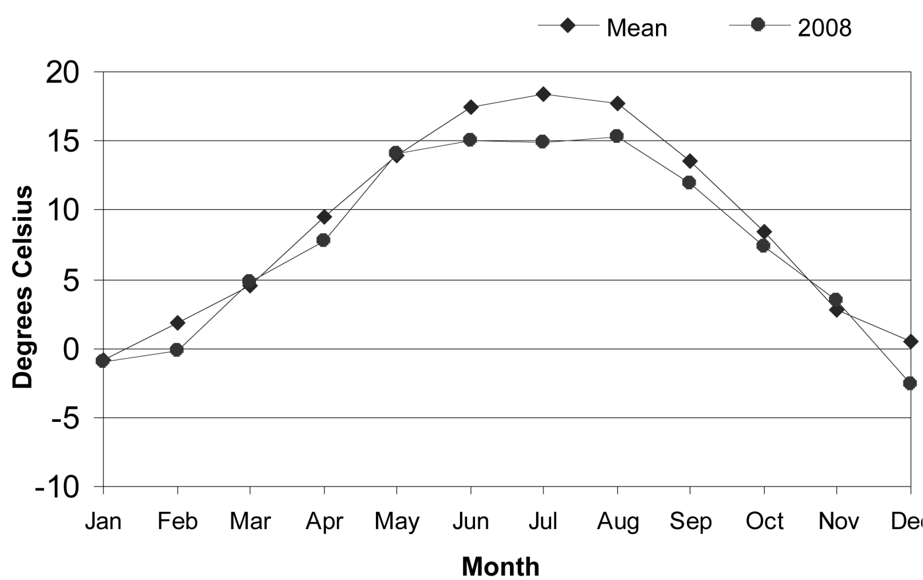


Figure 3. Average daily high air temperature: 2008 versus mean.

ers, because there was a poor set of most local berries, and raspberries went moldy before ripening.

The 2007-08 snowfall was well above average—121.3 inches (308.2 cm) compared to the average of 87.6 inches (189.7 cm). December 2008 had 28.6 inches (72.6 cm) snowfall, not greatly different from the average 21.0 inches (53.3 cm). However this snow fall did not penetrate through the tree cover, thereby leaving the ground uncovered and exposed to deep freezing during the middle of the month. This does not bode well for those animals (i.e., toads and some insects) and plants that depend on snow cover insulation during their winter hibernation. This also contributes to low stream flows during the winter when salmon eggs and fry are still in the stream bed gravel.

AIR TEMPERATURES

Monthly average air temperature followed much the same pattern as the SST. The monthly mean high temperature (Fig. 3) was below average from May through October. This was probably due to the near continuous cloud cover excluding incoming solar radiation. The monthly mean low temperatures were not significantly different for the long-term averages, while the mid-range temperatures were slightly below normal through the summer and early fall.

UPDATE

January 2009 was unusual by having alternating very cold and record warm periods along with record rains and record snows. With over 72.4 inches of snow and 9.65 inches of precipitation, January 2009 had the highest recorded January snowfall and precipitation at Auke Bay. The previous maximum snowfall for January was 71 inches in 1982. Previous maximum precipitation was 9.38 inches in 1985.

The 2008-09 seasonal snowfall has been the fifth highest in our Auke Bay records, with 147 inches of snow. Auke Bay sea surface temperatures remained near 1°C below average through March. The sea surface temperatures in the Northeast Pacific, Gulf of Alaska, and Bering Sea are also 1°– 2°C below average.

By Bruce Wing

MARINE ECOLOGY & STOCK ASSESSMENT PROGRAM

Tag Retention and Effects of Tagging on Movement of the Giant Red Sea Cucumber

Auke Bay Laboratories (ABL) researchers examined tag retention and the effects of tagging on short-term movements of the giant red sea cucumber (*Parastichopus californicus*). Retention rates were monitored for six different tag types (Floy banner FTSL-73, cinch FT-4C, fingerling FTF-69, garment and single T-bar FD-94, and the coded-wire tag), which were applied to 30 individuals under laboratory conditions.

The single T-bar and coded-wire tags had the highest retention rates, with 70% and 60% retention after 16 weeks and 40% and 37% retention after 32 weeks. To assess the effects of tagging and handling on movement, a field study was conducted in Amalga Harbor, Alaska, in which giant red sea cucumbers were tagged with T-bar tags (Fig. 4) and monitored for 24 hours. Tagged and handled animals moved significantly farther than control animals. The median (linear) distance moved by control animals over 24 hours was 1.8 m (range: 0.2–4.2 m), whereas the median distance for tagged animals was 4.2 m (range: 0.4–22.7 m). Short-term behavior was affected by both tagging and handling; therefore, we recommend that researchers minimize handling and wait at least 24 hours after tagging before monitoring *P. californicus* movements.

By Kristin Cieciel

Southeast Alaska: Oceanographic Habitats and Linkages

University of Alaska and ABL scientists conducted an overview of the physical oceanographic and geological processes that affect marine biological habitats and production in the marine waters throughout the archipelago and continental shelf of Southeast Alaska. Given the paucity of regional data, the overview summarizes work done in adjacent regions of the Gulf of Alaska shelf and basin and draws on research carried out in similar settings elsewhere.

The geological setting, which critically influences the regional meteorology and oceanography, includes a narrow continental shelf, deep channels that permeate the archipelago, fjords, glaciers, and a rugged, mountainous coast. The large-scale meteorology is influenced primarily by seasonal variations in the intensity and position of the Aleutian Low pressure center. Winds, freshwater runoff, tides, and cross-shelf exchange control the regional oceanography. The large-scale flow field advects mass, heat, salt, nutrients and planktonic organisms northward from British Columbia (and even farther south) to the northern Gulf of Alaska along the slope, shelf, and within the channels of Southeast Alaska. The deep channels permeating the island archipelago and narrow continental shelf facilitate transfer between basin and interior waters. Water properties and flow fields are subject to large annual variations in response to similarly large variations in winds and coastal freshwater discharge. The complex geological setting leads to large spatial heterogeneity in the physical processes controlling the local circulation fields and mixing, thereby creating numerous and diverse marine biological habitats. These various circulation and mixing processes substantially modify Southeast Alaska water masses and, thus, influence marine ecosystem processes downstream over the northern and western Gulf of Alaska shelf.

By Lisa Eisner

Figure 4. An underwater photograph of a tagged sea cucumber (*Parastichopus californicus*) in Amalga Harbor, Alaska. A black arrow indicates the location of a single T-Bar tag attached to the sea cucumber.

The Potential Role of Water-column Stability and Nutrients in Structuring the Zooplankton Community

The southeastern Bering Sea sustains one of the largest fisheries in the United States as well as wildlife resources that support valuable tourist and subsistence economies. The fish and wildlife populations in turn are sustained by a food web linking primary producers to apex predators through the zooplankton community. Recent shifts in climate toward warmer conditions may threaten these resources by altering productivity and trophic relationships in the ecosystem on the southeastern Bering Sea shelf. AFSC researchers from ABL and the Center's Resource Assessment and Conservation Engineering (RACE) Division in collaboration with University of Alaska Fairbanks scientists examined the zooplankton community near the Pribilof Islands and on the middle shelf of the southeastern Bering Sea in summer 1999 and 2004 to document differences and similarities in species composition, abundance, and biomass by region and year.

Between August 1999 and August 2004, the summer zooplankton community of the middle shelf shifted from large to small species. Significant declines were observed in the biomass of large scyphozoans (*Chrysaora melanaster*), large copepods (*Calanus marshallae*), arrow worms (*Sagitta elegans*) and euphausiids (*Thysanoessa raschii*, *T. inermis*) between 1999 and 2004. In contrast, significantly higher densities of the small copepods (*Pseudocalanus* spp., *Oithona similis*) and small hydromedusae (*Euphysa flammea*) were observed in 2004 relative to 1999. Stomach analyses of young-of-the-year (age 0) walleye pollock (*Theragra chalcogramma*) from the middle shelf indicated a dietary shift from large to small copepods in 2004 relative to 1999. The shift in the zooplankton community was accompanied by a 3-fold increase in water-column stability in 2004 relative to 1999, primarily due to warmer water above the thermocline, with a mean temperature of 7.3°C in 1999 and 12.6°C in 2004. The elevated water-column stability and warmer conditions may have influenced the zooplankton composition by lowering summer primary production and selecting for species more tolerant of a warm, oligotrophic environment. A time series of temperature from the middle shelf indicates that the warmer conditions in 2004 are part of a trend rather than an expression of interannual variability. These results suggest that if climate on the Bering Sea shelf continues to warm, the zooplankton community may shift from large to small taxa which could strongly impact apex predators and the economies they support.

By Lisa Eisner

Stock-Structured Distribution of Western Alaska Juvenile Chinook Salmon From United States BASIS Surveys, 2002-07

Stock distribution information from coded-wire tag recoveries and single nucleotide polymorphism (SNP) genetic markers of western Alaska juvenile Chinook salmon (*Oncorhynchus tshawytscha*) captured during U. S. Bering-Aleutian Salmon International Surveys (BASIS) are used to provide insight into Chinook salmon migratory patterns during their first summer at sea.

Juvenile Chinook salmon were primarily distributed within the coastal domain (bottom depths < 50 m) during mid-August to early October, 2002-07 (the time period sampled by the BASIS survey), and peak densities were observed adjacent to primary Chinook salmon-producing rivers in western Alaska. These distribution patterns reflect a lower apparent dispersal rate from ocean entry locations than other stream-type Chinook populations in the Gulf of Alaska. Chinook salmon stock mixtures did not support significant mixing of juveniles originating from the southern and northern Bering Sea shelf regions (south and north of 60°N) during their first summer at sea. Limited marine dispersal rates and limited mixing of stocks from different production region both support the assertion that regional abundance indices reflect regional production of juvenile Chinook salmon and are not confounded by significant stock mixing of juveniles from different production regions typically observed in the Gulf of Alaska. Coded-wire tagged juvenile Chinook salmon from the Whitehorse Rapids Hatchery in the Yukon River were captured near the Bering Strait during 2007 and provide evidence for the existence of a northern migratory corridor for juvenile Yukon River Chinook salmon. Northward migration of Yukon River Chinook salmon has not been observed in previous surveys; therefore, the anomalously warm conditions and extensive loss of sea ice during 2007 are believed to be the primary factors contributing to the occurrence of the northern migratory corridor.

By James Murphy

BASIS Symposium Held in Seattle

Dramatic fluctuations in the ocean growth and survival of many Asian and North American Pacific salmon populations over the past decade have been attributed to changes in the Bering Sea and other marine ecosystems. The absence of scientific observations for salmon, ecologically related species, and environmental conditions in the North Pacific Ocean has limited our understanding of these changes and how they affect salmon populations and economies around the Pacific Rim. International research efforts to address these issues were developed by the North Pacific Anadromous Fish Commission (NPAFC) as part of its science plan. The research plan, called BASIS (the Bering-Aleutian Salmon International Survey), began in 2002 as a coordinated program of cooperative research on Pacific salmon in the Bering Sea. The goal of BASIS research was to clarify the mechanisms of biological response by salmon to the conditions caused by climate change in the Bering Sea.

A symposium to discuss recent BASIS research was held 23–25 November 2008 in the Sheraton Hotel in Seattle, Washington. Ed Farley (ABL) chaired a steering committee consisting of Tomonori Azumaya, Richard Beamish, Ki Baik Seong, Vladimir Sviridov, and Shigehiko Urawa. During the symposium, the NPAFC commemorated the efforts from the research and contract vessels *Kaiyo maru* and *Wakatake maru* (Japan), *TINRO* (Russia), and *Sea Storm* and *Northwest Explorer* (USA) for their expertise and support in conducting BASIS research surveys.

The symposium focused on three main topics: 1) overviews of climate change, Bering Sea ecosystems, and salmon production; 2) biological responses by salmon to climate and ecosystem dynamics; and 3) discussion and summary on BASIS 2002–06: where do we go from here? There were 42 oral and 30 poster presentations. All presentations were in English.

It was evident from the symposium presentations that the Arctic is warming and that sea ice extent is declining.

By Jamal Moss

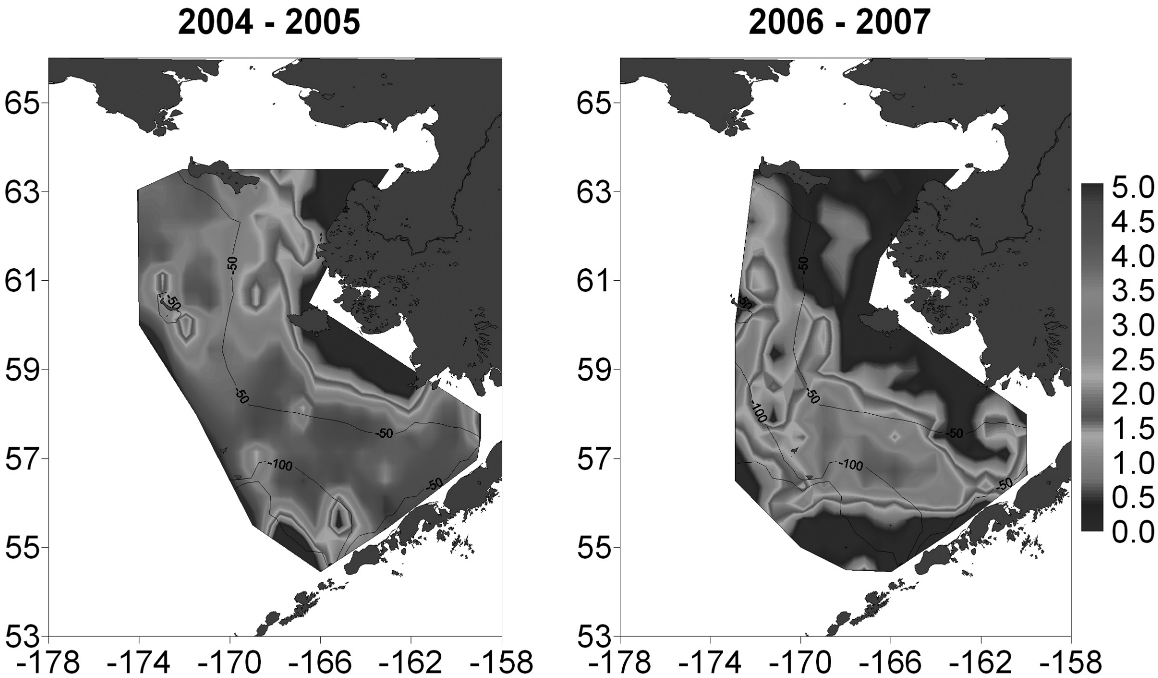


Figure 5. Spatial distribution of log transformed catch per unit effort (fish/m³) for age-0 walleye pollock sampled in early autumn during warm (2004–05) and cool (2006–07) years in the eastern Bering Sea.

Spatial Distribution, Energetic Status, and Food Habits of Eastern Bering Sea Age-0 Walleye Pollock

Age-0 walleye pollock were collected from the eastern Bering Sea during years when ocean temperatures were anomalously warm (2004–05) and cool (2006–07) see Figure 5. Variability in spatial distribution, food habits, energetic condition, and recruitment to the age-1 life stage was investigated in relation to thermal regime. Age-0 walleye pollock were large in size and widely distributed during warm years, whereas they were small and largely confined to the middle domain of the eastern Bering Sea during cool years. Energy density was positively correlated with body weight and was greater during years when conditions were anomalously cool. The proportion of smaller age-0 walleye pollock in the diet of larger individuals was high when conditions were warm (21.9% of diet by weight), and euphausiids were the most important prey (36.5% of diet by weight) when conditions were cool. Eastern Bering Sea age-0 walleye pollock were abundant and broadly distributed from Bristol Bay to offshore and northern locations during warm years; during cool years, age-0 fish were less abundant, and their distribution was constricted to the southeastern Bering Sea. An inverse relationship between brood year abundance and survival from age 0 to age 1 was found. Our results indicate that when spring/summer sea temperatures on the eastern Bering Sea shelf are very warm and when the water column is highly stratified during summer, age-0 walleye pollock allocate more energy to growth than to lipid storage, leading to low energy density before winter and thus to higher overwinter mortality.

By Jamal Moss

HABITAT ASSESSMENT, MARINE CHEMISTRY, & GENETICS PROGRAM

Winter Energy Dynamics in Two Populations of Juvenile Eulachon in Southeastern Alaska

Eulachon (*Thaleichthys pacificus*), an anadromous smelt occurring from northern California to southwestern Alaska, are probably best known for their high lipid content. With lipid comprising up to one-half of their dry mass, eulachon are one of the most energy-dense fishes in the North Pacific Ocean. Dried and equipped with a wick, eulachon have even been used as a light source, earning them the common name candlefish.

Spring spawning aggregations of eulachon attract large concentrations of marine and terrestrial predators at a critical time of the year when winter-depleted energy supplies need replenishment. In southeastern Alaska a single spawning run can attract hundreds of harbor seals, more than 1,000 Steller sea lions and bald eagles, and tens of thousands of gulls. Eulachon are also highly valued by native peoples along the Pacific Northwest coast, many of whom continue the tradition of harvesting eulachon for their rich oil.

Despite their ecological and cultural importance, the factors that influence eulachon populations are poorly understood. Size-selective winter mortality from starvation may play an important role in the recruitment success and, ultimately, abundance of eulachon. In north temperate fishes, lipid stores accumulated during summer and fall provide energy during winter when food abundance is low. Relative to older individuals, age-0 fish store less lipid prior to winter and metabolize energy faster, thereby increasing their susceptibility to winter starvation.

In 2007 AFSC scientists studied the overwinter (January-April) energy dynamics of age-0 and age-1 eulachon in two southeastern Alaska bays, Berners Bay and Fritz Cove. Age-0 eulachon in both bays began mid-winter with relatively less lipid than older eulachon despite allocating more of their surplus energy to lipid reserves. Midwinter lipid reserves were larger in Berners Bay fish than in Fritz Cove fish. However, fish from Fritz Cove maintained their energy levels from January to April, while fish from the Berners Bay suffered an energy deficit that was fueled primarily by metabolism of lipid and, to a lesser degree, protein. Age-0 eulachon in Berners Bay depleted more of their midwinter reserves than age-1 fish and metabolized more protein to meet energetic demands. The contribution of protein metabolism to this winter energy deficit increased with decreasing body size, suggesting that the smallest age-0 fish were most susceptible to starvation. A shift in the size-frequency distribution of both age groups in Berners Bay during winter may have resulted from the selective mortality of the smallest fish in the population. Although eulachon in both bays fed during winter, zooplankton were more abundant in Fritz Cove, suggesting that enhanced feeding opportunities may help to preserve lipid reserves and reduce starvation risk.

By John Hudson

Cardiac Arrhythmia Is the Primary Response of Embryonic Pacific Herring Exposed to Crude Oil during Weathering

Teleost embryos develop a syndrome characterized by edema when exposed to weathered crude oil constituents in water. Previous studies using zebrafish demonstrated that crude oil exposure causes cardiogenic edema, and that the most abundant polycyclic aromatic hydrocarbons (PAHs) in weathered crude oils (tricyclic fluorenes, dibenzothiophenes, and phenanthrenes) are cardiotoxic, causing arrhythmia through a pathway that does not require activation of the arylhydro carbon receptor (AHR). In Pacific herring *(Clupea pallasi),* a species impacted by the *Exxon Valdez* oil spill, the developing heart is the primary target of crude oil exposure. Herring embryos exposed to the effluent of oiled gravel columns developed dose-dependent edema and irregular cardiac arrhythmia soon after the heartbeat was established. At a dose that produced cardiac dysfunction in 100% of exposed embryos, tissue levels of tricyclic PAHs were below 1 μmol/kg, suggesting a specific, high affinity target in the heart. These findings have implications for understanding the mechanism of tricyclic PAH cardiotoxicity, the development of biomarkers for the effects of PAH exposure in fish, and understanding the long-term impacts of oil spills and other sources of PAH pollution in aquatic environments.

By Mark Carls

Fisheries Monitoring & Analysis (FMA) Division

FMA Works With Industry to Ensure Quality Data Collection

The Fisheries Monitoring and Analysis Division (FMA) deploys over 400 individual observers each year to vessels and processing facilities operating in the Bering Sea and Gulf of Alaska groundfish fisheries. Observers collect data that are used for quota monitoring, stock assessments, ecosystem investigations, and various research investigations. Observer work is often dependent on cooperation from the fishing industry to ensure that our information collection requirements are met. In this report we highlight the collaborative work between FMA staff and industry to enable observers to collect and transmit quality information to the National Marine Fisheries Service (NMFS).

Field office support

FMA maintains field offices in Dutch Harbor and Kodiak, Alaska. Each field office is run by one fishery biologist; additional staff are added during busy fishing seasons with the high volume of vessels and observers working out of Dutch Harbor. FMA field office staff serve as primary NMFS contacts for observed vessels and processing facilities in the Gulf of Alaska and Bering Sea, facilitate the collection of high quality data by observers, and act as liaisons between members of the industry and observers.

Work in the FMA field offices is a hands-on job requiring patience and flexibility. Fishing vessels arrive in Kodiak and Dutch Harbor at all hours of the day, and the ability of FMA staff to work a variable schedule is essential. During the peak seasons, work schedules are staggered to ensure that staff are in the office 7 days a week. FMA staff in Seattle and Anchorage also supplement the Dutch Harbor field office for a month or more on a rotating basis. Visiting staff in the Dutch Harbor field office have a variety of duties.

A top priority for field office staff is to conduct midcruise debriefing meetings with observers. These debriefings allow an observer to meet with a staff member during their deployment to review data collection methodology. Midcruise debriefings are vital to ensure that new observers collect data according to protocol and that vessel safety requirements are met. During these debriefings, FMA staff review the observer's data, discuss the observer's sampling design, ensure that other data types are collected correctly, and answer any questions regarding safety or sampling.

In some instances the vessel, observer, observer provider, or FMA staff may request a meeting prior to the first fishing trip. These meetings, coordinated by field office staff with the observer and key vessel personnel, help to establish a professional working relationship between the observer and vessel personnel. The objectives are to clarify what is expected of both the observer and vessel personnel and to provide both parties a chance to discuss any specific issues unique to the vessel. At the meeting, everyone is introduced and each participant gives a brief background of their work experience in fisheries. Each party is given a "Participants Responsibilities" document describing the vessel personnel responsibilities, the observer's responsibilities, and NMFS' responsibilities. Each section is reviewed and discussed by all participants to ensure that all participant's have a mutual understanding of each other's responsibilities. Details of the meeting are documented and kept on file.

Work in the dynamic production environment of a fishing vessel or processing plant can produce tension among the people involved. Occasionally, conflicts arise between industry personnel and observers or between two observers working together. When conflicts arise, FMA staff may intervene to help create a positive work environment, get the involved parties back to work, and to develop a proactive solution to the original problem.

At-sea data entry software support

FMA receives approximately 85% of observer data via satellite through a custom at-sea data entry software, in use since 1997. All groundfish vessels over 125 feet or those participating in specific fisheries are required to have this software and to maintain the communication system needed for

Figure 1. FMA staff member Jason Stern inspects the location of the observer's work table.

the observer to transmit data and messages to FMA staff. In 2008 FMA launched a new version of the software. Further improvements were made in 2009 which allow observers to send data daily over any type of satellite communication system. Industry assists by providing the computer and communications equipment. In December 2008 and January 2009, FMA staff traveled to Dutch Harbor to install the new software on more than 125 vessels and 25 plants and provide technical support to industry prior to the start of the groundfish fishing seasons. FMA field office staff provide continuing technical support to industry and observers throughout the year.

FMA staff monitor the data transmissions from all vessels and plants with the at-sea software to ensure that observers are transmitting data frequently to meet inseason fisheries management needs. If a problem arises and an observer is unable to transmit data, FMA works directly with the observer, vessel personnel, and observer contractors to resolve the problem. Typically, this can be done over the phone. If the problem can't be resolved remotely, FMA field office staff visit the boat to resolve the problem.

Sample station inspections

Federal regulations require that some vessels participating in limited access fisheries install sample stations that meet specific requirements and are for the sole use of fisheries observers. FMA staff support industry's efforts to meet these requirements by conducting annual vessel sample station inspections. (Figs. 1-2). FMA staff consult with fishing company representatives to ensure that the sample stations designed and installed aboard vessels comply with the regulations. When the vessels are in port, FMA staff inspect and certify the observer sample stations. All necessary elements of the sample station are documented on a checklist. A copy of this checklist is provided to the vessel company along with a notice of certification for the sample station. If the sample station fails any part of the inspection, FMA staff provide the vessel company with information on what needs revision, and the inspection is rescheduled to ensure that the revisions have been completed.

Each year as many as 59 vessels of varying sizes and gear types are inspected. Inspections are conducted throughout the Puget Sound region of Washington and at the Alaskan ports of Dutch Harbor and Kodiak. The bulk of the inspections occur prior to the start of major fisheries in Alaska. FMA staff are available for sample station consultations and inspections throughout the year and respond to requests within 10 days of receipt.

FMA's support activities provide needed services for members of the fishing industry and help to ensure that observers are able to collect high quality data and transmit these data in a timely manner. These activities are also valuable opportunities for personal interaction with industry, which improves our knowledge of fishing industry operations and helps to foster a good working relationship among members of industry, observers, and FMA staff.

By Allison Barns, Marlon Concepcion, Neil Riley, and Jason Stern

National Marine Mammal Laboratory (NMML)

ALASKA ECOSYSTEMS PROGRAM

Russian Steller Sea Lion Research Update

The National Marine Mammal Laboratory (NMML) has a long history of joint research on Steller sea lions in the Russian Far East. Beginning in the early 1990s, NMML scientists and scientists from TINRO (Russian Pacific Federal Fisheries Research Institute, Vladivostok) have worked collaboratively on joint surveys on Soviet scientific expeditions to the Kuril and Aleutian Islands to examine

Figure 2. FMA staff member Ben Riedesel takes notes during a vessel sample station inspection.

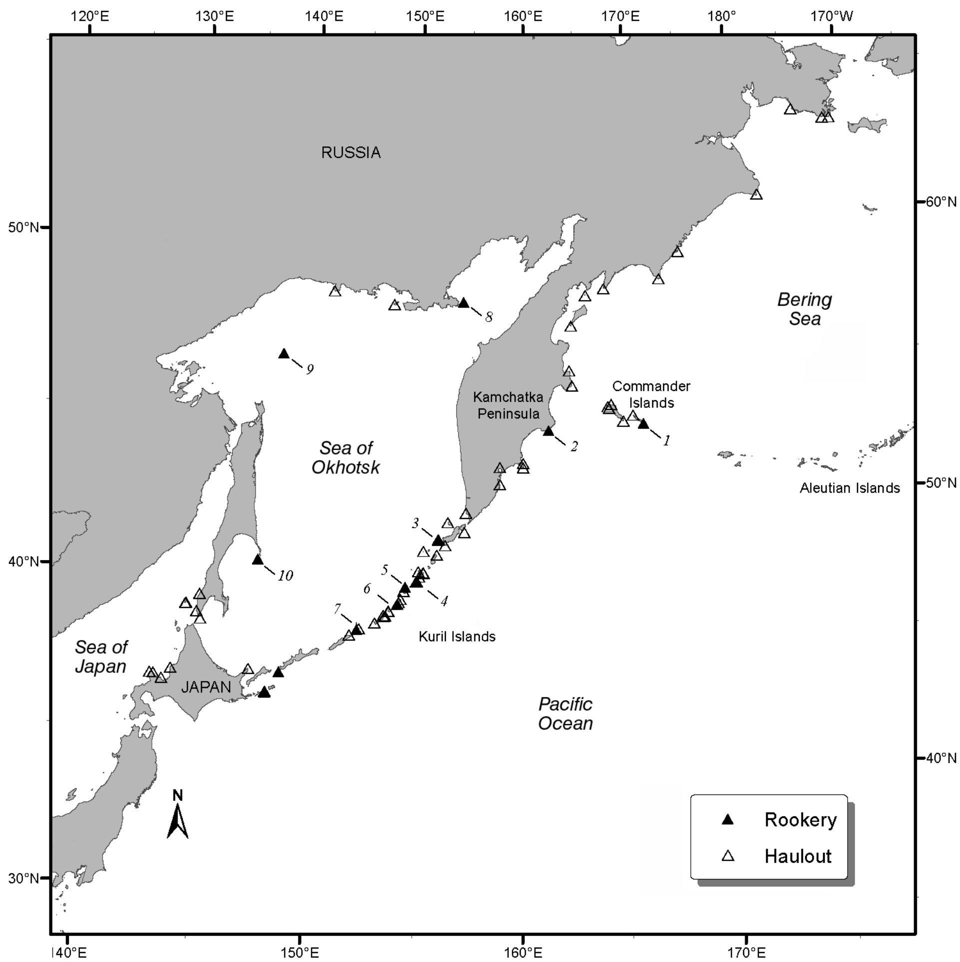


Figure 1. Major rookeries and haulouts of Steller sea lions along the Asian coast: 1) Medny Island; 2) Kozlov Cape; 3) Antsiferov Island; 4) Lovushki Island; 5) Raykoke Island; 6) Srednego Island; 7) Brat Chirpoev Island; 8) Yamsky Islands; 9) Iony Island; 10) Tuleny Island.

Steller sea lion rookeries and mark pups for estimation of vital rates. In recent years, this work has continued in cooperation with the Alaska SeaLife Center, Kamchatka Institute of Geography of the Russian Academy of Sciences, and a number of other Russian scientific research institutes and organizations (Sevvostrybvod, TINRO, Komandorsky Reserve, Vyatskaya Agricultural Academy, Pacific Oceanological Institute) under the title of Project 02, "Marine Mammals," a section within Area V of the U.S.-Russia Agreement on Cooperation in the Field of Environmental Protection.

ABUNDANCE MONITORING

In Russia, aerial surveys of Steller sea lions are not possible due to the lack of appropriate aircraft and the absence of a sufficiently developed network of airports necessary to safely operate, refuel, and maintain planes. Therefore, rookery surveys intended to monitor changes in population trends are conducted from vessels and inflatable boats during the sea lion reproductive period (June–July). Steller sea lions in Russian waters range over an extremely large area (Fig. 1), such that surveys are staggered among different areas in different years (Table 1). Results of surveys in adjacent years and adjacent areas are combined to determine total population in the region and to estimate trends. Results indicate that abundance varies in different areas (Table 1, Fig. 2). For example, in the western part of the Bering Sea, on the Commander Islands, and along the east coast of Kamchatka, the species' abundance has remained low with an insignificant downward trend after a sharp decrease in the 1980s. At the same time on the Kuril Islands, along the Sakhalin coast and in the northern part of the Sea of Okhotsk, the trend has been positive. Collectively, data from 2006–08 suggest that about 18,000 sea lions haul out on Russian rookeries during the reproductive period (Table 1). Considering that during the direct survey approximately 30% of the juvenile and adult animals stay in the water and are not counted, the total population of Steller sea lions in Russia can be estimated to be approximately 25,000 animals. There is concern about the low number of breeding Steller sea lions on the coast of east Kamchatka and on the Commander Islands. Although the Commander Islands Steller sea lions inhabit Russian waters, they are genetically part of the western stock that ranges from the Commanders to Cape Suckling, just east of Prince William Sound.

PUP BRANDING AND SAMPLING

In the Russian Far East, the first attempts at tagging newborn Steller sea lion pups to study their winter migrations occurred during the mid-1960s. However, the sample sizes were small (45 pups), and the work did not provide any useable results. Ultimately, several more attempts were made to tag pups

Table 1. Counts of Steller sea lions in Russia, June–July 2001–08 (all sites, ages, and sexes combined).

Year	Western Bering Sea	Commander Islands	East Kamchatka	Kuril Islands	Tuleny, Sakhalin	Northern Sea of Ohkotsk
2001		946	748	6,840	1,160	3,683
2002	18	774	626		1,451	3,077
2003		746		6,775	1,599	
2004	135	895	683		1,592	4,346
2005				7,685	1,625	
2006		931	678		1,590	4,575
2007				10,185		
2008	110	890	679			

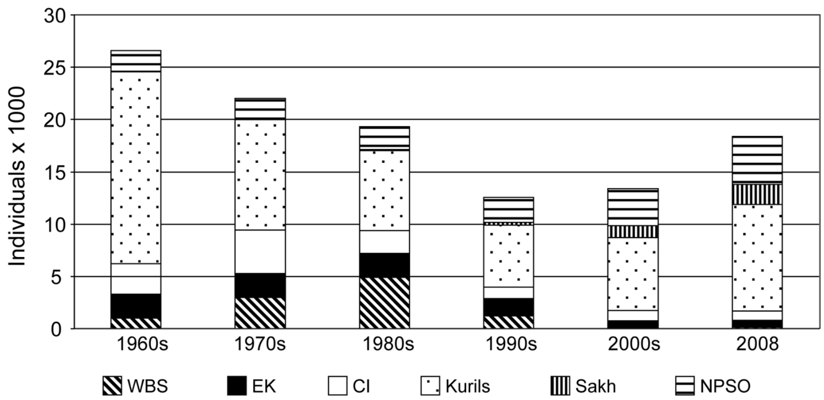


Figure 2. Changes in abundance of Steller sea lions in Russia, 1960s–2000s (trend sites combined): NPSO = northern part of the Sea of Okhotsk; Sakh = Tuleny Island, Sakhalin; Kurils = Kuril Islands; CI= Commander Islands; EK = East Kamchatka; WBS = western Bering Sea.

with metal and plastic tags, and the results of this work provided the first data on migrations of young Steller sea lions between rookeries and haulouts. However, these tags were only retained for 3-4 years. The first mass branding of pups in Russia was performed during the joint research cruise of TINRO and NMML scientists in summer 1989, and branding has been carried out regularly since 1996 (Table 2). In total, 8,486 Steller sea lions have been marked on 9 of the 10 major Steller sea lion rookeries in Russian waters, including 1,524 sea lions that were tagged with front flipper tags and 6,962 that were branded (Fig. 1, Table 2). In parallel with pup branding, morphometric data (body length, axillary girth, and weight) were regularly collected and, beginning in 2002, a small tissue sample was taken from each branded pup for genetic research. In addition, blood samples were collected from 10-30 animals at each site to monitor health conditions and for archival purposes.

OBSERVATIONS OF BRANDED SEA LIONS

In Russia, observations of branded Steller sea lions are carried out mainly on the breeding rookeries (Table 3). Two or three observers spend up to 3 months camped near 8 of the 10 primary rookeries to collect daily resights of branded sea lions. As with similar work in Alaska, digital photos are collected for verification of the encounter and for positive identification of individual animals (photos of brands are compared with the brand resight database). For juvenile animals (ages 1-3), all observations note the presence or absence of a tending adult female, and for mature females the presence of an older dependent or a newborn pup is also noted. All observations also note whether the adult female is nursing and if any copulations are observed. Data are entered into a database daily.

In addition to the ground-based observations on the rookeries, vessel surveys over large areas are conducted to record and photograph branded sea lions seen on haulouts, and similar data are collected on reproductive status. Ultimately, all of this information is collated at the completion of the field season and combined into a single Steller sea lion brand resight database. All the data received from occasional respondents—fishermen, hunters, local residents, etc.—are also entered in this database. Data on the branded sea lion encounters along the coast of Hokkaido (Japan) are regularly provided by students of Hokkaido University and biologists from the Hokkaido National Fisheries Research Institute. There are currently more than 100,000 records about encounters of 2,648 branded Steller sea lions in the database.

DISPERSION AMONG ROOKERIES

We used the annual sightings of sea lions on the rookeries to examine the level of mixing and dispersion among those rookeries (Fig. 3). On average, 21% (0%-33%) of the marked population resighted on rookeries during the breeding season were nonresident animals (of all ages and sexes born at different rookeries). Approximately 24% (0%-44%) of the mature females (age 4+) were nonresidents, while only 9% (0%-19%) of females that gave birth were nonresidents. More nonresident individuals of all ages and sexes were recorded on rookeries that were within 100 km of another rookery (Lovushki and Raykoke Islands) or located at specific geographic areas close to common migration routes (Antsiferov and Tuleny Islands and Kozlov Cape). The minimum distance between natal and breeding rookery among nonresident marked females was 45 km, and the maximum was over 1,400 km. A high level of isolation was recorded for the remote sites of Medny Island (Commander Islands) and the Yamsky Islands in the Sea of Okhotsk. A newly established rookery was discovered on Tuleny Island in the 1980s, and we found that sea lions on this site primarily dispersed from the northern part of the Sea of Okhotsk (Iony and Yamsky Islands) but not from the Kuril Islands, as was previously believed. During the breeding seasons of 2002–07, 332 marked sea lions (of all ages and sexes) from seven rookeries were encountered on Tuleny Island. Approximately 71% (236) of those animals came from the northern part of the Sea of Okhotsk (mainly from Iony Island) and only 29% (96) from the Kuril Islands. Steller sea lions from Kamchatka or the Commander Islands were not encountered on this rookery. An interesting

Table 2. Summary of Steller sea lion branding and tagging in Russia, 1985–2008.

Year	ROOKERY											TOTAL		Grand Total
	Manati	Medny	Kozlov	Zheleznaya	Antsiferov	Raykoke	Lovushki	Srednego	Brat Chirpoev	Iony	Matykil'	MPT*	Brand	
1985	2											2		2
1987	20											20		20
1988	8											8		8
1989	3					**139**	**200**	**200**	**200**			3	**739**	742
1991		50				100	200		100			450		450
1992		100	82	12								194		194
1993		100	74									174		174
1994		100	47									147		147
1995		100	50			101	100	100				451		451
1996		**100**	**50**		**100**	**100**	**100**		**100**				**550**	550
1997		25	**50**		**100**	**100**	**100**		**100**	**100**		25	**550**	575
1998		**87**	**50**		**100**	**100**		**100**	**100**	**150**			**687**	687
1999		**100**	**50**		**50**	**100**	**100**	**80**	**100**				**580**	580
2000			50								**90**	50	**90**	140
2001		**95**			**100**	**100**	**100**	**100**	**76**	**143**	**81**		**795**	795
2002		**85**	**50**							**100**	**150**		**385**	385
2003		**54**			**100**	**100**	**77**	**100**	**100**				**531**	531
2004		**100**	**50**							**150**	**150**		**450**	450
2005					**100**	**100**	**105**	**100**	**100**				**505**	505
2006		**100**	**50**							**150**	**150**		**450**	450
2007					**100**	**100**	**100**	**100**	**100**				**500**	500
2008		**100**	**50**										**150**	150
Total MPT	33	475	303	12		201	300	100	100			1,524		
Total brand		**821**	**400**		**750**	**939**	**882**	**780**	**976**	**793**	**621**		**6,962**	
Grand Total	33	1,296	703	12	750	1,140	1,182	880	1,076	793	621	1,524	6,962	8,486

*MPT = metal or plastic tags.

Numbers in regular font are metal or plastic tags.

Numbers in bold font are brands.

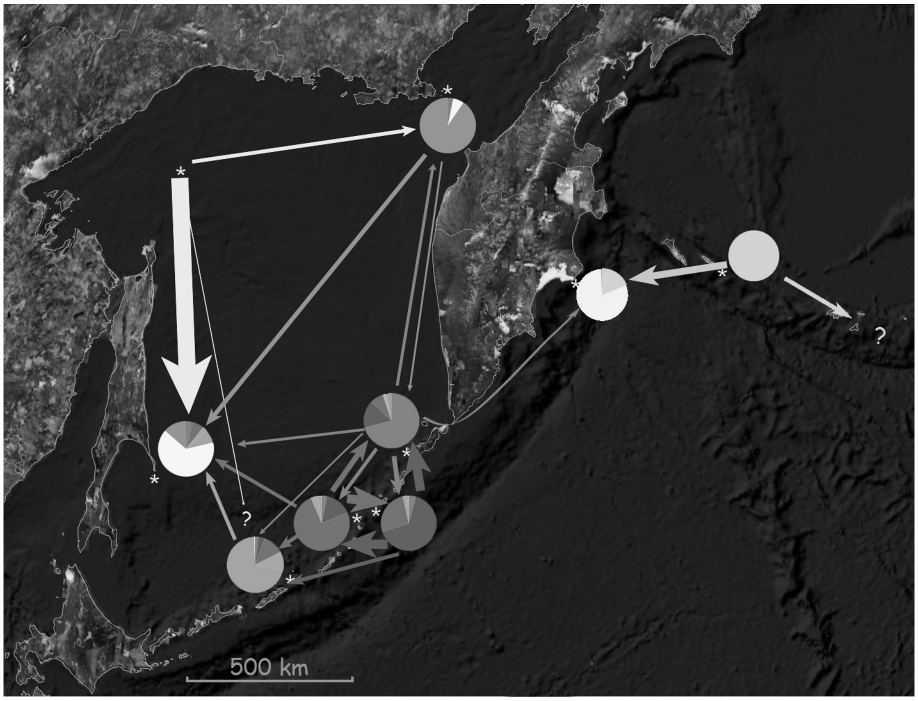


Figure 3. Preliminary analysis of direction of dispersal and mixing of Steller sea lions on rookeries during the reproductive period, 2002–07 (females of age 4+).

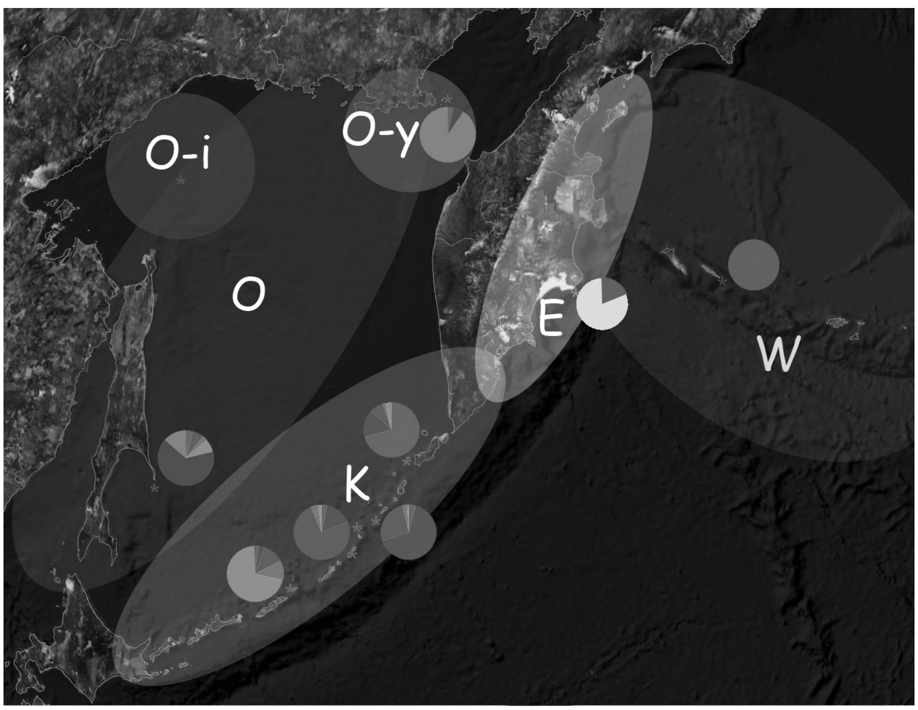


Figure 4. Preliminary data on stock structure of Steller sea lions in Asia: W = Commander Islands (western population); E = East Kamchatka; K = Kuril Islands; O = Sea of Okhotsk; O-i = Iony Island; O-y = Yamsky Islands.

phenomenon of a one-way dispersal of sea lions between the Commander Islands and Kamchatka Peninsula was also noted. Of 721 sea lions branded on Medny Island (Commander Islands), 19% (134) repeatedly traveled to Kozlov Cape (Kamchatka Peninsula) in 2002–07. The distance between these rookeries is 415 km, but some animals visited both rookeries during one season. Three branded females from Medny Island gave birth to pups and copulated on Kozlov Cape. Of 350 Steller sea lions branded on Kozlov Cape during the same time, none were ever observed on Medny Island. For unknown reasons, dispersion of animals between these rookeries occurs in only one direction—from Medny Island to Kozlov Cape. We used repeated encounters of 5,242 marked Steller sea lions to examine the current metapopulation structure of Steller sea lions in Asia (Fig. 4.) Currently, there are four relatively independent reproductive groups (subpopulations) in the Russian Far East: Commander Islands, Kamchatka, Kuril Islands, and the Sea of Okhotsk. The Commander subpopulation inhabits waters near the Commander Islands, the east coast of Kamchatka, and the western part of the Bering Sea. Steller sea lions from this subpopulation are also widespread to the east from the Commander Islands and have been observed along the Aleutian Islands, near the Pribilof Islands, in Bristol Bay, near Kodiak Island, and along the Kenai Peninsula coast in the Gulf of Alaska. The home range of the Kamchatka subpopulation mainly covers the waters along the east coast of Kamchatka and the western part of the Bering Sea. Some juvenile males from Kozlov Cape have been observed in the northern half of the Kuril Islands. The Kuril subpopulation breeds on the Kuril Islands, but its home range stretches from the Olutorsky Gulf in the western part of the Bering Sea to the coast of China, including the coast of Hokkaido Island and all of the Sea of Okhotsk. The Sea of Okhotsk subpopulation breeds mainly in the northern part of the Sea of Okhotsk and near the Sakhalin coast. Possibly, it consists of two smaller, relatively isolated reproductive groups, located on Iony and Yamsky Islands. The home range of this subpopulation includes all of the Sea of Okhotsk, the coast of Hokkaido, and the northern part of the Sea of Japan (up to the Tatar Strait). Juvenile males are regularly encountered near the Kuril Islands and southeast Kamchatka coast. A thorough genetic analysis of over 3,000 skin biopsy samples from the Russian population is being used to examine the levels of genetic isolation that may be present within the population.

STELLER SEA LION DIET IN RUSSIAN WATERS

Between 2001 and 2008, more than 3,000 scat samples were collected for prey studies. Preliminary processing (washing) of the samples was carried out on the research

Table 3. Steller sea lion brand resight effort (days) on Russian rookeries during the breeding season, 2002-08.

Rookery	2002	2003	2004	2005	2006	2007	2008	Total
Medny/Yugo-Vostochny	78	83	73	86	80	87	71	558
Kozlov Cape	52	47	43	64	81	60	3	350
Antsiferov/rookery	33	53	57	49	60	47	45	344
Lovushki/Dolgaya	35	51	55	54	59	51	38	343
Raykoke	39	52	54	54	56	44	24	323
Brat Chirpoev/rookery	37	50	51	54	55	43		290
Sakhalin/Tuleny	59	43	40	28	30	33		233
Yamsky Islands				34	38	43		115
Total	333	379	373	423	459	408	181	2,556

vessels and frozen samples were then sent to NMML or the Alaska SeaLife Center. Preliminary results indicate that in Russia the diet of Steller sea lions consists of at least 83 prey types (50 of which have been identified to species). According to the frequency of occurrence, the top 10 species are Atka mackerel *(Pleurogrammus monopterygius)*, walleye pollock *(Theragra chalcogramma)*, Pacific salmon *(Oncorhynchus* spp.*)* sculpins *(Cottidae)*, cephalopods, Pacific sand lance *(Ammodytes hexapterus)*, Pacific herring *(Clupea pallasii)*, northern smoothtongue *(Leuroglossus schmidti)*, snailfish *(Liparidae)*, and Pacific cod *(Gadus macrocephalus)*. Plotting the results of the cluster analysis by geographic location resulted in seven distinct geographic areas of prey similarity: northern Kamchatka Peninsula, southern Kamchatka Peninsula, Commander Islands, northern Kuril Island rookeries, northern Kuril Island haulouts, southern Kuril Islands, and the northern Sea of Okhotsk. There was no significant relationship between diet diversity and rookery population trends. For example, the southern Kuril Islands had the highest level of diet diversity but had a relatively stable population trend, whereas, the southern Kamchatka Peninsula had the second highest level of diet diversity but also the second highest level of population decline. The 10 most common prey items consumed by Steller sea lions in the Russian Far East were similar to those consumed by the western stock in Alaska waters; however, the proportions consumed were significantly different. This difference is primarily due to the greater occurrence of sculpins in the Russian sea lions' diet.

By Vladimir Burkanov

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

Cook Inlet Beluga Whale Aerial Surveys, September–October 2008

Scientists from the National Marine Mammal Laboratory's (NMML) Cetacean Assessment and Ecology Program (CAEP), along with colleagues from the NMFS Alaska Regional Office conducted two aerial surveys focused in Cook Inlet, Alaska, on 19-20 September and 22 October 2008. These surveys were an exploratory effort to look for beluga whales (*Delphinapterus leucas*) in Kamishak Bay, with a secondary objective to test paired video cameras during the September survey.

We flew a total of 8.9 flight hours during four flights in September and 3.5 flight hours during one flight in October. The survey on 19 September included a coastal trackline (1.4 km offshore) down the western side of the inlet from the Little Susitna River to Cape Douglas, mid-inlet tracklines, and a coastal trackline along Kachemak Bay (Fig. 5). On 20 September, we flew a coastal trackline of the upper inlet north of Point Possession and the Beluga River tidal flats (Fig. 6). During the October survey, the team transited to Cape Douglas and began a coastal survey north to the Little Susitna River (Fig. 7). Poor sighting conditions and high winds precluded any exploration of the smaller bays along Kamishak Bay in October.

Belugas were not observed in lower Cook Inlet (south of lat. 60°43'N) during either the September or October surveys. Marine mammals observed on 19 September included 25 harbor seals (*Phoca vitulina*) hauled out in Tuxedni Bay, 317 sea otters (*Enhydra lutris kenyoni*) in groups (average group size = 7; median = 3) in Kachemak Bay, 12 harbor seals in Kachemak Bay, 15 Steller sea lions (*Eumetopias jubatus*) hauled out north of Cape Douglas, 15 sea otters in scattered small groups (average group size = 1.4; median = 1) from Cape Douglas to Iniskin Bay in Kamishak Bay, a dead beluga stranded in Turnagain Arm, and a small group of belugas swimming near McHugh Creek in Turnagain Arm (Fig. 5). Samples from the dead beluga were collected later that evening. During the upper inlet survey on 20 September, belugas were found in Turnagain Arm (three groups: ranging from 17 to 29 whales), Chickaloon Bay (one group: 11 whales), and Knik Arm (two groups: a single whale and a group of 5 whales) (Fig. 6). No marine mammals were observed during the 22 October survey.

Wide-angle video footage of beluga groups in Turnagain Arm (15 video passes) was collected on 20 September for testing purposes. For 3 years (2003–05), Cook Inlet beluga abundance surveys relied on a mini-digital video camera with a resolution of 720 x 480 pixels (a Sony DVCAM, DSR-PDX10 Model L10A). However, with advancements in technology, we replaced this camera in 2006 with a new HD (high-definition) digital video camera (JVC GR-HD1), which provided a higher resolution of 1280 x 720 pixels. The Sony DVCAM video camera was placed alongside the HD JVC video camera in order to collect comparable video footage on both cameras. The video footage will be analyzed at NMML to determine if the change in resolution influences the detection of beluga whales.

The September and October 2008 surveys continued the time series document-

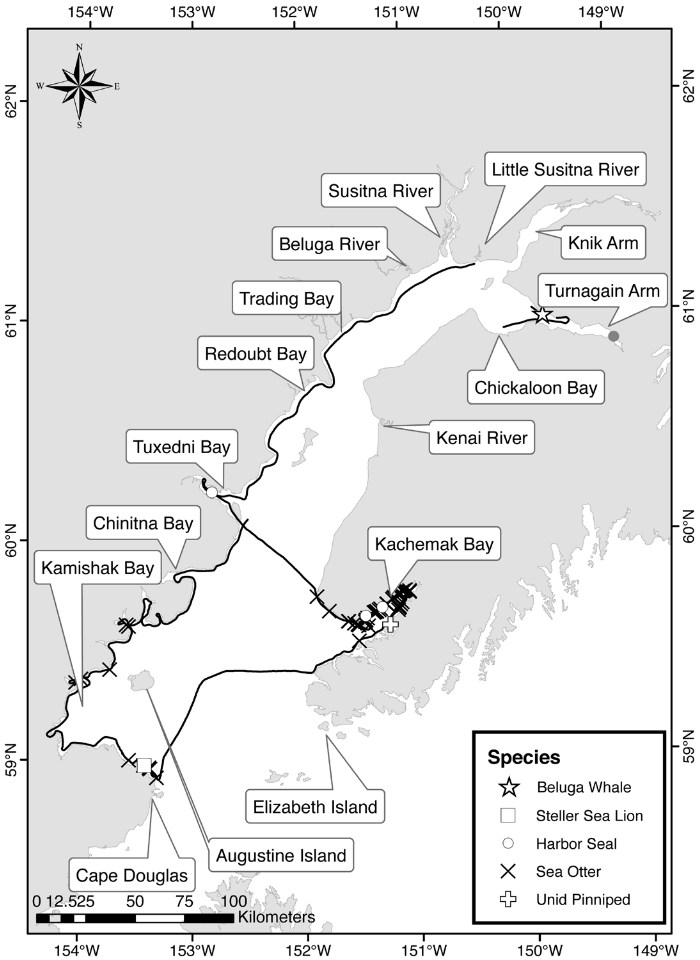


Figure 5. On-effort trackline and marine mammal sightings during the 19 September 2008 aerial survey of Cook Inlet, Alaska.

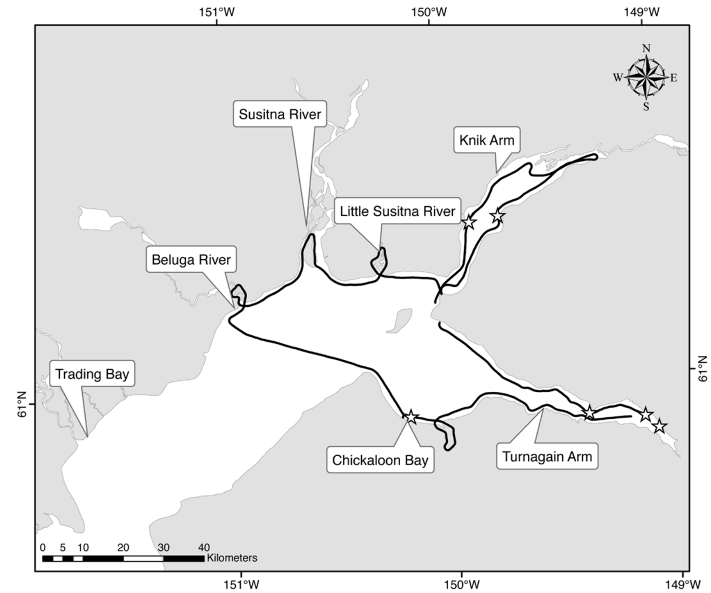


Figure 6. On-effort trackline and beluga sightings (stars) during the 20 September 2008 aerial survey of Cook Inlet, Alaska.

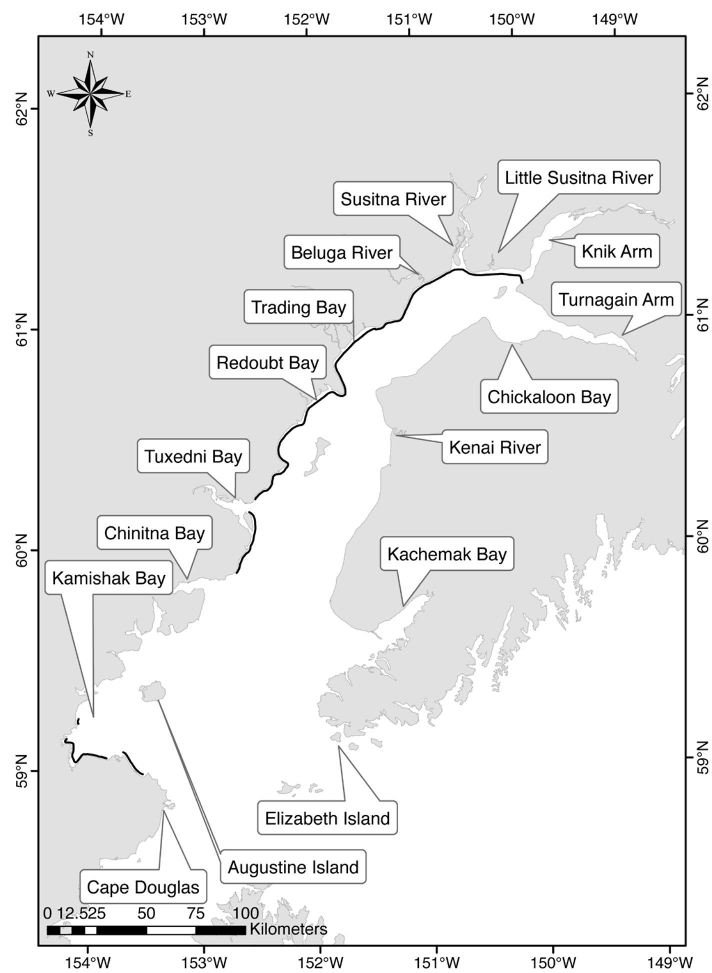


Figure 7. On-effort trackline during the 22 October 2008 aerial survey of Cook Inlet, Alaska.

ing beluga distribution in months other than June, with a primary objective to document beluga whale presence in lower Cook Inlet. Although no belugas were sighted in lower Cook Inlet during the September and October 2008 aerial surveys, opportunistic sightings of belugas in Bruin Bay on 17 September and in Iliamna Bay in October indicate that, at times, belugas are using the lower inlet bays during the fall. Continued monitoring of opportunistic sightings and follow-up exploratory surveys of the lower inlet will be needed to confirm the presence and extent of use of these lower inlet bays by Cook Inlet belugas.

By Christy Sims, Kim Shelden, and Kim Goetz

POLAR ECOSYSTEMS PROGRAM

Long-Term Satellite Tags on Ribbon Seals Begin to Pay Off

In February 2009, the Polar Ecosystems Program (PEP) received data transmitted from a satellite tag deployed in May 2007 on a ribbon seal in the central Bering Sea. This represents a deployment length of more than 620 days. We believe this may be the longest deployment of a satellite tag on a marine mammal. This particular ribbon seal traveled into the eastern Siberian Sea in summer 2007 and then returned to the Bering Sea in spring 2008 (Fig. 8). The lat-

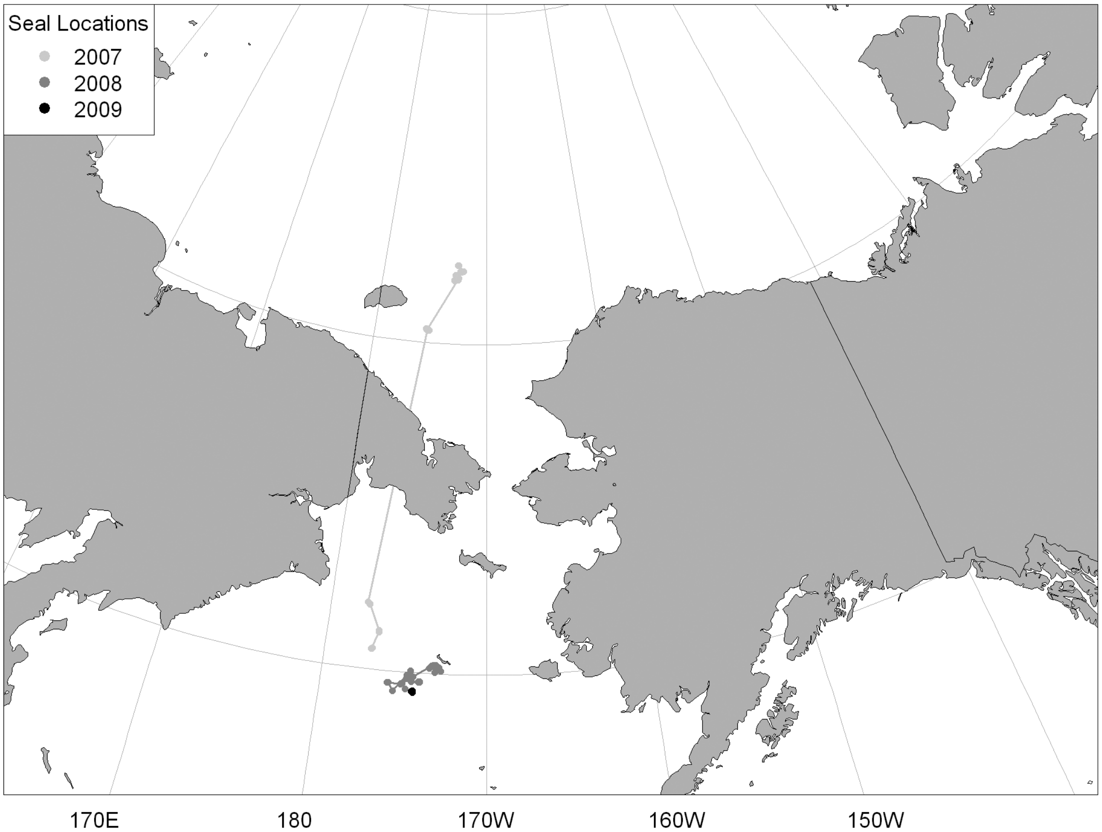


Figure 8. Multiyear movements of a ribbon seal tagged by the Polar Ecosystem's Program in May 2007.

est location was along the sea-ice edge, 135 km southwest of St. Matthew Island.

The satellite tag was designed and developed in cooperation with Wildlife Computers (Redmond, Washington) and is attached to the rear flipper of the seal. The tag measures 3 inches x 0.75 inches x 0.33 inches and is glued to a cattle ear tag for secure attachment to the inter-digital webbing of the rear flipper. Because the tags are attached to the rear flippers, they only transmit to the ARGOS satellites when the animal is out of the water, resting on sea ice. We are especially interested in the behavior of ribbon seals during the pupping, breeding, and molting season when they are often found within the marginal sea-ice zone. Therefore, we have programmed the tags to come on for 4 hours every 4 days from 1 April to 30 June and twice a month during the rest of the year. The 4-hour period corresponds with the period of maximum satellite coverage in the Bering Sea. This increases the quality of determined location and bandwidth of data transmission. In addition to providing locations, the tags also record and transmit timelines of haulout behavior. This provides us with information on how the seals are using sea ice during this critical time and also helps us correct aerial surveys to account for seals that are in the water.

Tags were also deployed on other ribbon seals and spotted seals during spring 2007 and 2008. We hope to receive transmissions from additional animals as we move into spring 2009. We will be conducting additional captures off the NOAA ship *McArthur II* from mid-May to mid-June 2009 and will be deploying a new version of these tags with twice the battery life.

By Josh London

Resource Assessment & Conservation Engineering (RACE) Division

GROUNDFISH ASSESSMENT PROGRAM

Integrated Ocean and Coastal Mapping Workshop

Integrated Ocean and Coastal Mapping (IOCM) is an emerging NOAA-wide initiative 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 "map once, use many times."

Scientists from all NMFS Science Centers met with representatives from the hydrographic surveying side of NOAA and other Federal agencies in Silver Spring, Maryland, on 18-19 March 2009. Based on a 5-year planning horizon, the workshop objectives were to 1) create a better understanding of ocean and coastal mapping activities across NOAA so that NOAA programs can better coordinate and 2) gather input on and build support for a proposed vision and business model for NOAA IOCM. In addition to broad NOAA representation, the U.S. Army Corps of Engineers and U.S. Geological Survey also participated in the workshop. A series of presentations by experts on various aspects of hydrographic surveying, NOAA vessels, and digital data products comprised the workshop agenda, which in turn served as background for small working groups charged to discuss coordination, data standards and management, technology development and enhancement, and outreach and communications. A seminar preceding the workshop given by AFSC scientist Bob McConnaughey titled "Basin-scale habitat studies in the eastern Bering Sea" provided a fisheries perspective to attendees and demonstrated the value of quantitative acoustic data from the seafloor for objectively characterizing the essential fish habitat (EFH) of groundfish and crab species.

The proceedings demonstrated a clear need for greater coordination of the diverse ocean and coastal mapping activities occurring in the U.S. EEZ (exclusive economic zone). Because mapping costs are high and suitable ship time is limited, it was recognized that better communication amongst those engaged in ocean and coastal mapping was a critical function to be provided by an expanded IOCM organization. To this end, there was broad consensus that dynamic internal and external websites are needed to provide details on NOAA vessel capabilities, to identify projects already completed, and to identify projects still being planned (to promote efficient use of limited resources). These Web sites could also be configured to improve data tracking, encourage creation of Federal Geographic Data Committee-compliant metadata, and monitor overall progress toward the common National Geophysical Data Center (NGDC) data repository. The workshop planning team and facilitators are reviewing and summarizing the workshop breakout session results as part of the process leading to NOAA-wide coordination of ocean and coastal mapping in the next 5 years.

By Bob McConnaughey

Figure 1. The U.S. Coast Guard icebreaker *Healy* breaks ice in the northern Bering Sea. Photo courtesy of Andrew Trites, University of British Columbia.

Figure 2. Fine-arts photographer An-my Lê captures on-ice research activities during the BEST/BSIERP northern Bering Sea research cruise. Photo courtesy of Andrew Trites, University of British Columbia.

Habitat Research Team Ventures Into the Northern Bering Sea

With global climate change, there is increasing interest in the Alaskan Arctic regarding loss of sea ice and ecosystem effects that will alter the fish community. Fisheries oceanography models indicate that the distribution ranges of fish stocks, particularly flatfishes and crabs, may extend northward with the warming of the Arctic Ocean and diminishing sea ice. The National Marine Fisheries Service is taking the initiative to investigate and gather information to manage marine resources in the Arctic and formulate strategies in anticipation of the impacts of climate change on fisheries and the ecosystem.

The Bering Ecosystem Study (BEST) and the Bering Sea Integrated Ecosystem Research Program (BSIERP) were conceived to support research on scientific and socio-economic issues related to climate change in the eastern Bering Sea. NOAA works in close partnership with these programs to ensure the best science and emergent findings are available to inform management. As part of these collaborative efforts, more than 30 scientists participatied in a BEST/BSIERP research cruise which departed for the northern Bering Sea in March 2009 aboard the U.S. Coast Guard's *Healy* (Fig. 1), its newest and largest icebreaker. Chief scientist Lee Cooper, a benthic ecosystems expert at the University of Maryland Chesapeake Bay Laboratory (CBL), led the scientific party, which included scientists studying sea ice communities, optics, zooplankton biogeography, biogeochemistry, and anthropology.

Academic institutions represented included Smith College; the Scripps Institution of Oceanography; the University of Alaska Fairbanks; the University of Maryland CBL; University of Southern Illinois; University of Tromsø, Norway; the Ocean University of Tsingdao, China; the University of British Columbia, and the University of Victoria, Canada. Government agencies represented were the National Park Service, the North Pacific Research Board, U.S. Fish and Wildlife Service, U.S. Geological Survey, and NOAA. The outreach effort was tremendous, including print, radio, and television journalists, a fine arts photographer (Fig. 2), and a PolarTREC teacher. Interactive presentations of the project were made in real-time from the ship to school children in the United States and Europe via satellite.

Representing NMFS, Cynthia Yeung of the AFSC's Habitat Research Group participated in the cruise to investigate the benthos of the northern Bering Sea and to gather ideas and methods in benthic ecosystem studies that are relevant to the AFSC's own habitat research. Yeung was part of the cruises' benthic studies team led by Dr. Jackie Grebmeier of the University of Maryland CBL, who has been studying benthic-pelagic coupling in arctic and subarctic waters for over two decades. Through her long-term observations, Grebmeier has acquired unique insights into not only the changes occurring in the Bering Sea, but also the practicalities of conducting research there.

Figure 3. Walruses peeking through ice holes. Photo courtesy of Andrew Trites, University of British Columbia.

Figure 4. Members of the the walrus tagging team. Photo courtesy of Andrew Trites, University of British Columbia.

Four days' sailing from Kodiak, Alaska, led the *Healy* to thick ice near St. Lawrence Island. Forty-three benthic sampling stations were located mainly to the south of the island. Many of these stations were ice-bound and required the icebreaking capabilities of the *Healy*. A van Veen grab was deployed at each station to collect multiple infauna and sediment samples. The infauna samples were sieved on deck, and the animals were preserved. Sediment samples were taken for grainsize, chlorophyll, and nutrients analyses. On-station activities also include the deployment of conductivity-temperature-depth (CTD) and optical instruments to characterize the biochemical and physical properties of the water column, bongo nets for collecting zooplankton, and a HAPS corer to obtain undisturbed sediments for incubation experiments. With temperatures colder than -20°C in the first week, keeping instruments functional on deck was a major challenge. Sieve boxes, sediment samples, and even hot water hoses were frozen—a testament to the difficulty of Arctic research and the tenacity of the researchers.

The region's featured megafauna are seabirds and marine mammals, particularly the spectacled eiders and walruses (Fig. 3). These keystone species are dependent on the benthic communities of mollusks, crustaceans, and polychaetes for food and are vulnerable to climate and anthropogenic changes affecting the ecosystem. The *Healy*'s onboard helicopter transported scientists studying walrus (Fig. 4) and eider to search for their subjects on the ice. Scientists also went on the ice to collect cores and sample the communities and conditions underneath the ice. At those ice stations, an armed watch was set against polar bears, and a Coast Guard rescue diver stood by. Net, core, and grab sampling (Figs. 5 and 6), and laboratory experiments were conducted around the clock. In addition to all this, a series of evening talks provided topics ranging from arctic ecology to climbing Mt. McKinley. The commander of the *Healy*, Captain Frederick Sommer, gave a tantalizing talk on Coast Guard history, highlighting an overland rescue expedition from Cape Vancouver to Barrow, Alaska, in 1897.

The BEST/BSIERP programs showcase exciting and innovative research and render it accessible to all who are concerned about the Bering Sea ecosystem. On the *Healy*, dedicated researchers from diverse disciplines conferred to seek a comprehensive knowledge of how climate change may affect nature and society. With the benthic grab and impressed with the significance of the benthic community in the Bering Sea ecosystem, the AFSC Habitat Research Group will turn its focus this summer on cruises to the southeastern Bering Sea, where benthic sampling will be integrated into our studies of the habitats and ecology of managed species.

By Cynthia Yeung

Figure 5. A benthic grab deployment aboard the U.S. Coast Guard icebreaker *Healy*. Photo courtesy of Tom Van Pelt, North Pacific Research Board.

Figure 6. Brittlestar and other infauna from the benthic grab. Photo courtesy of Tom Van Pelt, North Pacific Research Board.

Species Identification Confidence in the Eastern Bering Sea Shelf Survey

The Resource Assessment and Conservation Engineering (RACE) Division has been conducting bottom trawl surveys of the eastern Bering Sea continental shelf since the early 1970s. Information gathered from this summer survey provides fisheries-independent population trends that are invaluable for stock assessments and development of management strategies for commercially exploited fish and invertebrate species in the region. Throughout the history of the survey, changing priorities and limited resources have led to fluctuations in the quality and specificity of field identifications for some taxa. As an increasing number of users request access to survey data for use in a broad diversity of studies, we feel that it is important to provide users with a tool to help assess the confidence level that should be assigned to identifications of each taxon throughout the history of the survey. Therefore, we have created an identification confidence matrix for fishes and invertebrates identified in the survey from 1982 through 2008. For each survey year, every species was assigned an identification code indicating the level of confidence on correct identification for that time period, with "1" indicating high confidence and consistency, "2" indicating moderate confidence, and "3" indicating low confidence.

The index is unavoidably subjective but was influenced by several factors, including relevant taxonomic literature, available field identification tools, inter-annual reporting trends, and examination of collected specimens. The tables are intended to serve as a general guideline in assessing the relative historical reliability of the species identification data in this time series and will be made widely available through print and the internet as a resource for EBS shelf survey data users.

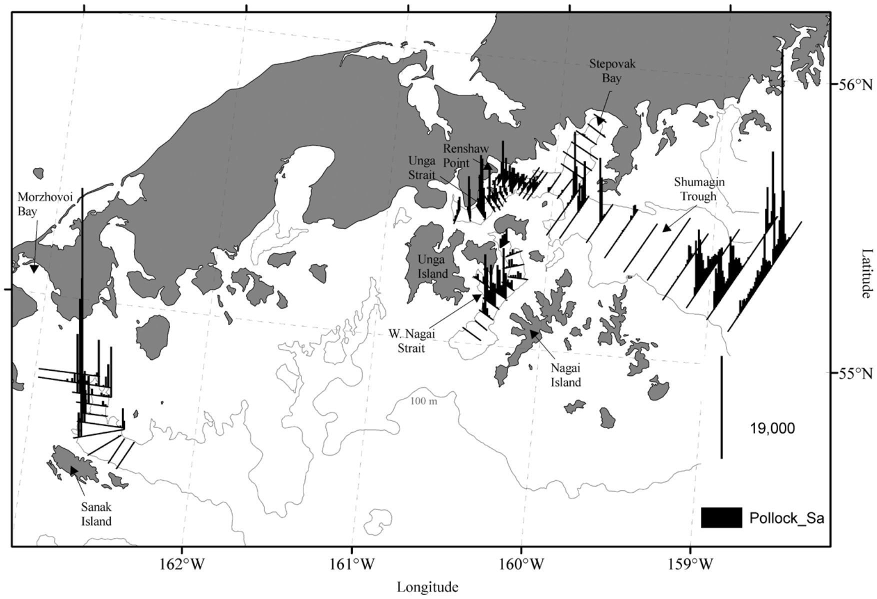
By Duane Stevenson and Gerald Hoff

MIDWATER ASSESSMENT & CONSERVATION ENGINEERING (MACE) PROGRAM

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

Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program conducted winter echo integration-trawl surveys aboard the NOAA ship *Oscar Dyson* 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 during 11-21 February included the Shumagin Islands and Sanak Trough (Fig. 7) and the GOA shelfbreak between Sanak and Unimak Islands (not pictured). Between 19 March and 1 April, GOA surveyed areas included the Chirikof shelfbreak, Shelikof Strait, and Marmot Bay (Figs. 8-9). The area in the vicinity of Bogoslof Island in the Bering Sea was surveyed from 7 to 15 March (Fig. 10). All surveys were conducted 24 hours per day.

Survey results indicated that walleye pollock abundance increased in 2009 compared to 2008 in the Shumagin Islands area, in Sanak Trough, and in the Shelikof Strait area but decreased dramatically along the GOA shelfbreak in the vicinity of Chirikof Island. The densest walleye pollock aggregations were located in the southern part of Shumagin Trough, off Renshaw Point, along the western sides of the Sanak Trough (Fig. 7) and shelf to the west, within Shelikof Strait proper between Cape Kuliak and Wide Bay, and west of Spruce Island in Marmot Bay (Fig. 8). Few pollock were encountered in the two shelfbreak areas surveyed. Moderate to dense aggregations of



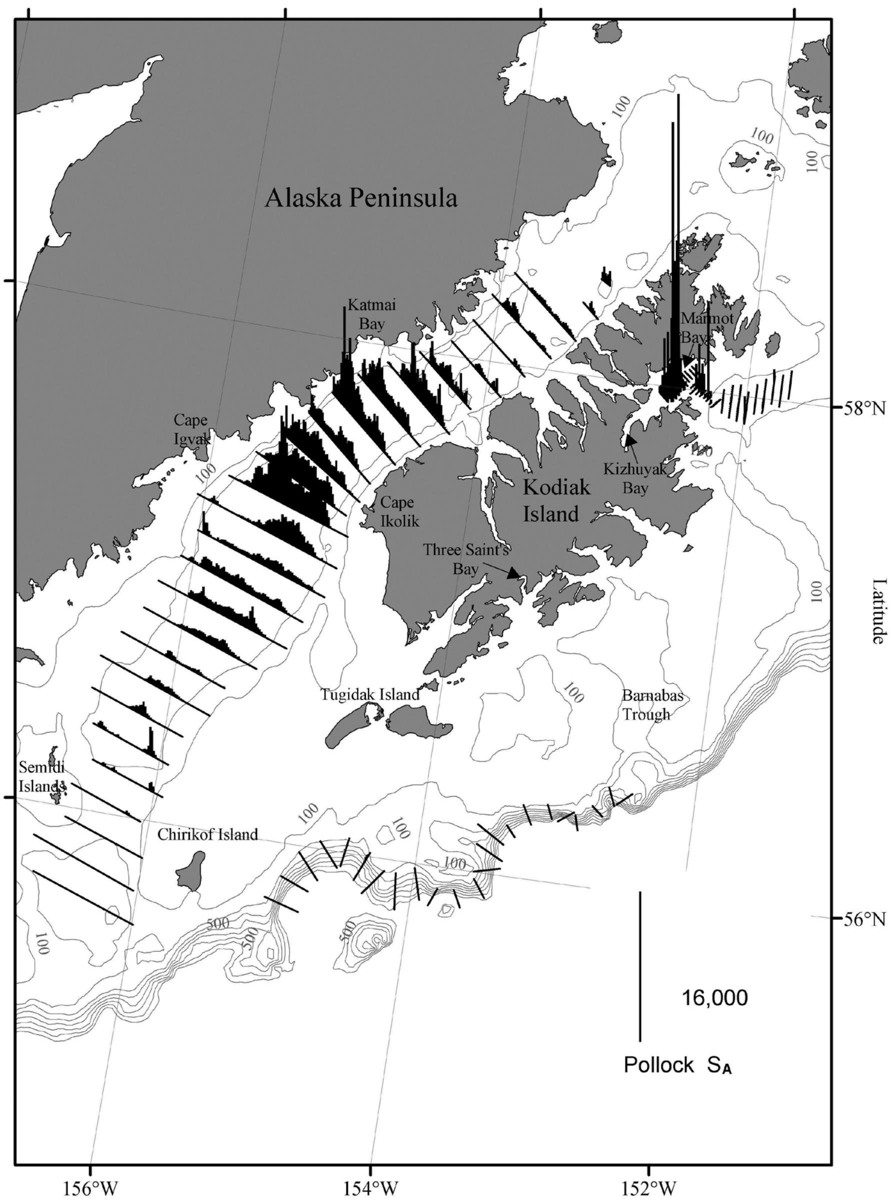


Figure 7 (*Top*). Acoustic backscattering (sA) attributed primarily to walleye pollock (vertical lines) along transects during the 11-21 February 2009 acoustic-trawl surveys of the Shumagin Islands and Sanak Trough in the Gulf of Alaska.

Figure 8 (*Bottom*). Acoustic backscattering (sA) attributed primarily to walleye pollock (vertical lines) along transects during the 19 March-1 April 2009 acoustic-trawl surveys along the Gulf of Alaska shelf break from Chirikof Island to Barnabas Trough, the Shelikof Strait area, and Marmot Bay.

Pacific ocean perch (*Sebastes alutus*), however, were found over much of the Chirikof shelfbreak over bottom depths of 200-300 m (Fig. 9).

In the Shumagin Islands area, 11-cm fork length (FL) mode (age-1), 21-cm FL mode (age-2), and 27-cm FL mode (age-3) fish were most abundant. In the Shelikof Strait area, the size composition consisted of a mixture of age-1, age-2, and older adult fish, with older fish dominating the deepest part of the strait between Cape Kuliak and Wide Bay and younger fish dominating elsewhere. The size composition for Sanak Trough was unimodal, with most fish between 50- and 65-cm FL. The size composition for Marmot Bay was dominated by a strong mode at 39-cm FL, with older fish ranging between 45- and 70-cm FL. Preliminary analysis of maturity stages indicated that survey timing was appropriate for all areas except Sanak Trough, where an earlier survey would be better.

The 2009 walleye pollock abundance estimate in the southeastern Aleutian Basin near Bogoslof Island was lower than the estimate from our previous survey of this area in 2007. Most of the adult pollock were concentrated north of Samalga Pass with a minor component distributed northeast of Umnak Island (Fig. 10). The pollock size composition ranged between 41-cm and 70-cm FL in both areas and was characterized by a dominant mode at about 55 cm FL. Preliminary analysis of maturity stages indicated that the majority of female pollock were prespawning in both the Samalga and Umnak regions, indicating that the survey timing was consistent with historical efforts.

By Taina Honkalehto

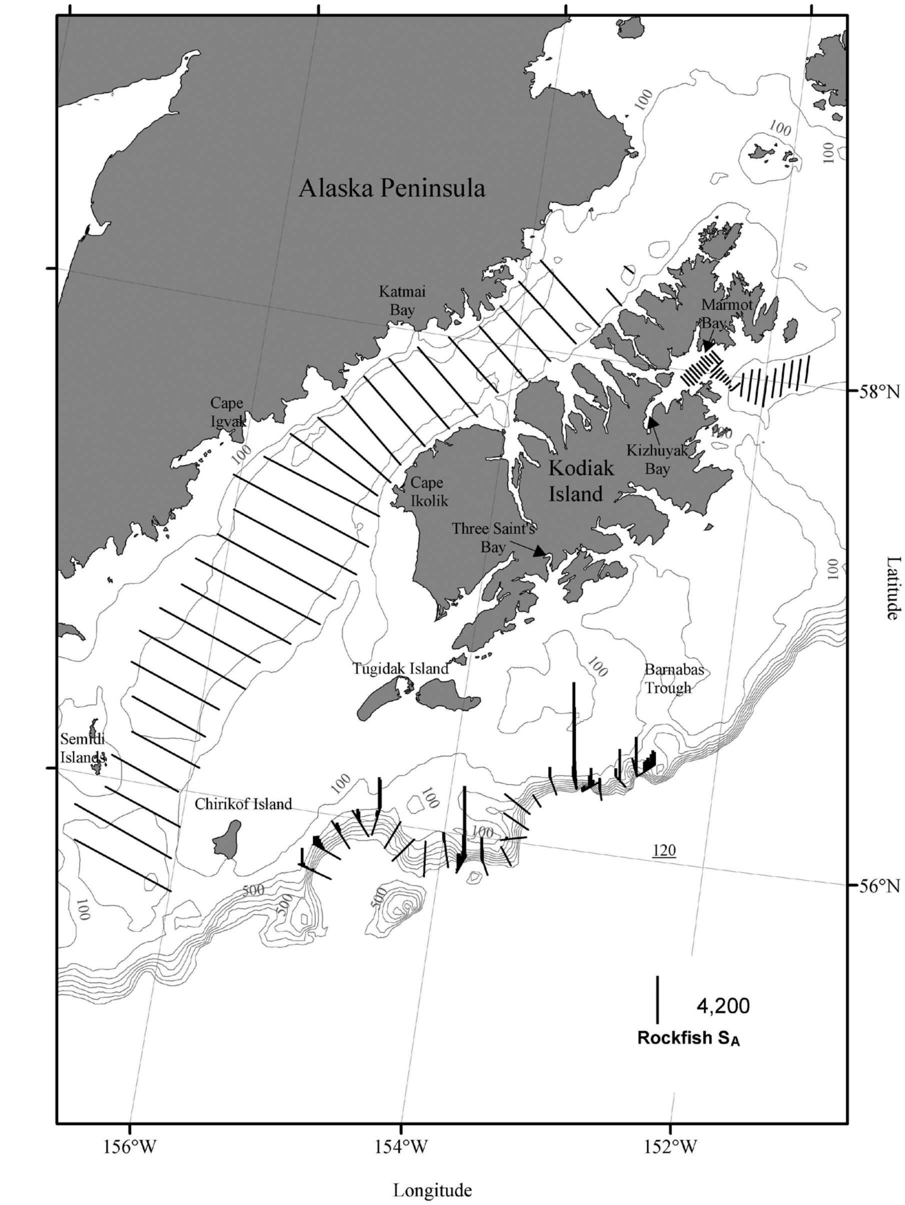


Figure 9 (*Top*). Acoustic backscattering (sA) attributed primarily to Pacific ocean perch (vertical lines) along transects during the 19 March-1 April 2009 acoustic-trawl surveys along the Gulf of Alaska shelf break from Chirikof Island to Barnabas Trough, the Shelikof Strait area, and Marmot Bay.

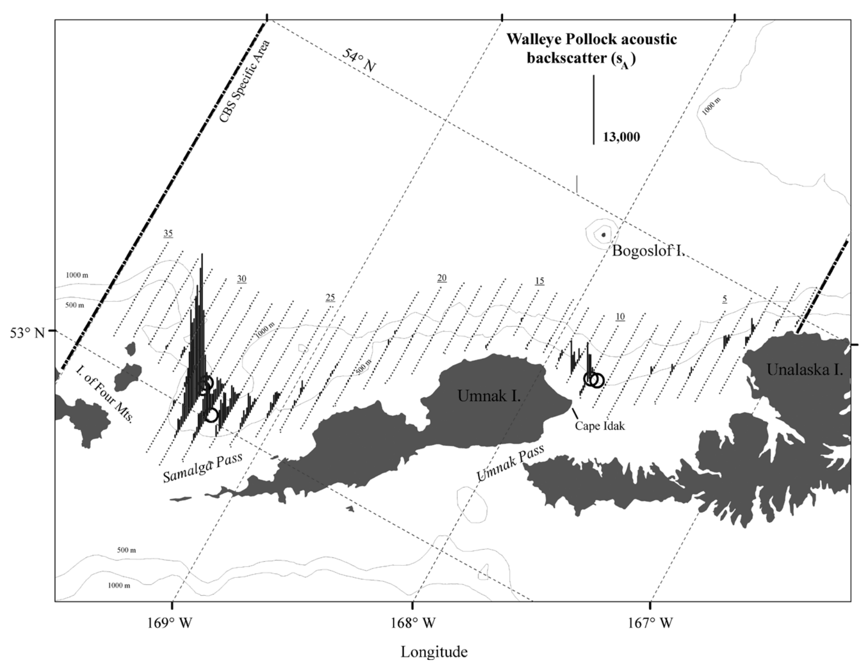


Figure 10 (*Bottom*). Acoustic backscatter (sA) attributed to walleye pollock (vertical lines) along tracklines during the 7-15 March 2009 acoustic-trawl survey of walleye pollock in the southeast Aleutian Basin near Bogoslof Island. Trawl haul locations are indicated by circles, and the Central Bering Sea Convention area is indicated by a dash-dotted line.

SHELLFISH ASSESSMENT PROGRAM – KODIAK LABORATORY

2009 Lowell Wakefield Fisheries Symposium

The 25th Lowell Wakefield Fisheries Symposium entitled Biology and Management of Exploited Crab Populations under Climate Change took place in Anchorage, Alaska, 10-13 March 2009. The approximately 80 participants comprised crab biologists and managers from the United States, Canada, Greenland, Japan, Norway, and Australia. The symposium consisted of six sessions covering the following topics: 1) abundance and distribution; 2) measurement of disease and effects of environmental stressors; 3) reproduction and size at maturity; 4) life history, habitat use, and predation; 5) stock- and environment-recruitment relationships; and 6) stock enhancement and culture. Many of these session topics have been the focus of the Shellfish Assement Program at the Kodiak Laboratory (KL), so the laboratory actively participated at the symposium with KL personnel taking the lead on seven presentations and posters and also being co-authors on an additional five presentations and posters. Eight publications are pending as a result of the symposium (Table 1).

Crab abundance and distribution in the eastern Bering Sea (EBS) is one focus of the shellfish survey and assessment group. Surveys of crab abundance and distribution have occurred for decades although time series data for the early Bering Sea surveys are not well developed. Malley and Foy presented efforts to rescue and retrieve historic Bering Sea crab data. Over 71,000 records from 1966-74 surveys that include embedded environmental data have been scanned, archived, and entered into a searchable database. The relational database will serve research and modeling efforts concerning population dynamics, fishery management, and ecology. Although most of the focus historically has been on the EBS shelf, crabs on the continental slope have been assessed periodically. Haaga et al. examined the abundance and bathymetric distribution of these largely unstudied crabs along the slope and found that *Chionoecetes* sp. biomass showed a downward trend from 2002 to 2008, while *Lithodes* sp. increased during the same period. (Fig. 11a). The majority of *C. bairdi* and *C. opilio* occurred at depths of 200-400 m and *C. tanneri* were found at 400-1,000 m. Biomass for *L. aequispina* decreased with depth, while *L. couesi* biomass increased from 600-1,200 m. Overall, the largest biomass encountered along the slope was *C. angulatus*, with the largest numbers found below 800 m. (Fig. 11b). Although the commercially important species of *C. bairdi* and *C. opilio* utilize the Bering Sea slope areas, it appears that the total biomass is small and they are located in areas that are likely not well suited to commercial fishing.

Researchers with the Shellfish Assessment Program have conducted many studies to understand the complex reproductive dynamics of numerous crab species with the ultimate goal of using this information to improve crab management. In recent years, the program has been collaborating with Alaska Department of Fish and Game (ADF&G) and the University of Alaska Fairbanks (UAF) studying egg production of Bristol Bay red king crabs (*Paralithodes camtschaticus*) for the development of biological reference points. Swiney et al. presented a portion of this research comparing spatial and temporal variability in red king crab fecundity. Bristol Bay 2007 and 2008 fecundities did not differ; however, those years were significantly more fecund than Bristol Bay in the 1980s, and Bristol Bay 2008 was significantly more fecund than southeastern Alaska in 2008 (Fig. 12). Thus, variability in fecundity should be considered in development of biological reference points, stock assessment, and management models. Red king crab reproductive dynamics are also impacted by environmental variability caused by decadal and climate influences. Chilton et al. looked at the impact of temperature variability on female Bristol Bay red king crab distribution and reproductive cycles from 1998 to 2008. Mature females were distributed in nearshore areas that were relatively warmer (3°-4°C) than the cold pool (<2.0°C) that extended onto the Bristol Bay shelf in "cold" years. The ratio of mature females with eyed embryos compared to females with uneyed embryos increased dramatically in early June for the five cold years since 1998 (Fig. 13). The distribution of mature females in colder years

Table 1. Shellfish Assessment Program publications pending inclusion in the 25th Lowell Wakefield Fisheries Symposium: Biology and Management of Exploited Crab Populations Under Climate Change symposium proceedings.

Authors	Title
E. A. Chilton, C. E. Armistead, and R. J. Foy	Reproductive timing of Bristol Bay red king crab and the cold pool intrusion
K. M. Swiney, J. B. Webb, G. H. Bishop, and G. L. Eckert	Variability and measurement of Alaska red king crab fecundity
S. L. Persselin and B. Daly	Assessment of diet and water source on cultivation of red king crab (*Paralithodes camtschaticus*) larvae
D. Urban	Seasonal predation of Pacific cod on Tanner crab in Marmot Bay, Alaska
S. B. Van Sant, F. Tapella, and C. Romero	Effects of temperature and rearing density in golden king crab (*Lithodes aequispinus*) larval cultivation
C. L. Worton, D. Urban, K. M. Swiney, Z. Grauvogel, and S. Byersdorfer	Is the commercial size limit of Dungeness crabs in Alaska appropriate based on their size at physiological and functional maturity?
M. S. M. Siddeek, L. Rugolo, J. Zheng, and J. Turnock	The new precautionary control rules for Bering Sea and Aleutian Islands crab fisheries management
J. Zheng, D. Pengilly, R. J. Foy, and D. Barnard	Stock assessment model evaluation for St. Matthew blue king crab

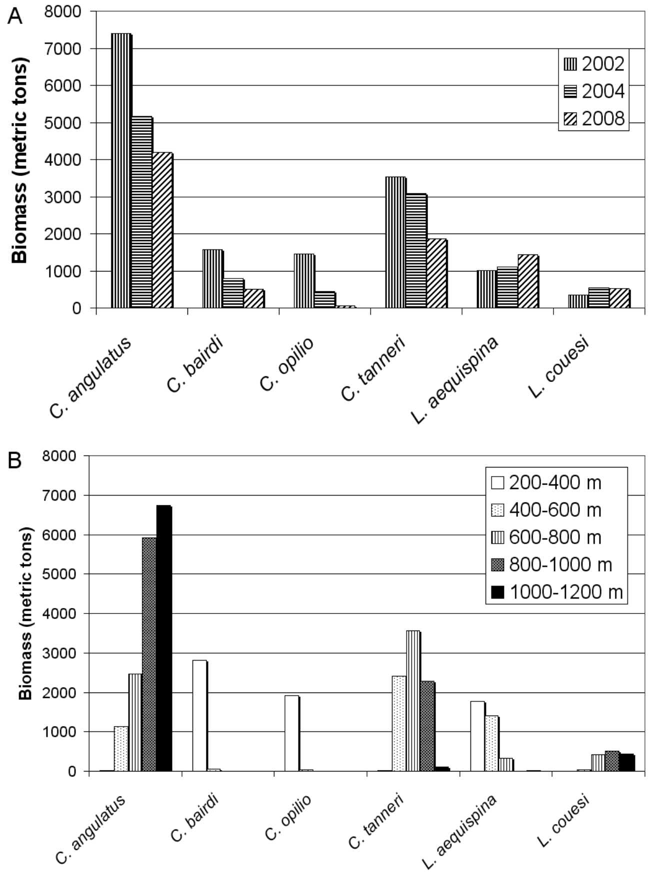


Figure 11. Biomass of *Chionoecetes* (*C.*) and *Lithodes* (*L.*) species encountered on the eastern Bering Sea slope survey, 2002, 2004 and 2008. (A) Biomass by year; all depths combined, (B) biomass by depth; years 2002, 2004 and 2008 combined.

coupled with delayed embryo development and subsequent larval hatching could affect larval survival and dispersion as well as the mating potential between mature male and female red king crab. Lastly, basic life history studies are still needed to adequately manage crab stocks in Alaska. Urban and Swiney collaborated with ADF&G to establish whether the commercial size limit of Dungeness crabs (*Cancer magister*) in Alaska is appropriate based upon their size of physiological and functional maturity. Determining accurate size at maturity of crabs is a management need as legal catch size limits are typically set to ensure that males have an opportunity to mate at least once before recruiting to a fishery. Worton et al. reported a smaller size of male functional maturity than was previously reported, but cautioned that the noncompetitive laboratory studies employed in this study do not account for the complexities of mating dynamics and recommended that the size limit not be changed until laboratory results are validated with in situ studies.

KL researchers are also interested in trophic interactions between groundfish and crab stocks in Alaska. Urban presented the results of a study examining the predator/prey relationship between Pacific cod (*Gadus macrocephalus*) and Tanner crab to better understand crab stock recruitment and fluctuations. Analysis of data from a joint NOAA Fisheries and ADF&G study conducted in Marmot Bay off Kodiak June 1998 through June 1999 revealed that cod consumed over 365 million Tanner crabs from three separate cohorts, removing 81% of the 1997 cohort. The relationship between predation rates and crab population was shown to be density-dependent, indicating that cod may work to stabilize local Tanner crab populations.

The KL remains instrumental in king crab culture and enhancement research in Alaska. Eckert et al. provided an overview of the Alaska King Crab Research, Rehabilitation, and Biology (AKCRRAB) program which the KL researchers have a large involvement in. To date, researchers in that program have demonstrated that king crab can be cultured in a hatchery on a large scale. Persselin and Daly also examined ways to improve red king crab larval survival in culture by assessing diets and water sources in two separate experiments. Mean survival to the glaucothoe stage was significantly higher, and mean larval duration was significantly shorter on a diet enhanced with natural cold water diatoms (*Thalassiosira nordenskioeldii*) than without. Also, it was found that using artificial seawater was not any better for culturing larvae than using natural seawater. Van Sant et al. compared the survival, larval duration, and density of golden king crab (*Lithodes aequispina*) larvae reared at 4° and 6°C. Decreased temperature was found to delay molting and larval duration but did not reduce survival to the glaucothoe or crab 1 instars. Density did not significantly affect survival in this study. Cultivation techniques reported are useful for future research on settlement behavior and habitat preference which are dependent on the production of an adequate number of glaucothoe and juveniles.

The program remains highly involved in assessment and management of crab stocks, especially in the development and implementation of the 2008 U.S. federal fishery management plan (FMP) for Bering Sea king and Tanner crabs. Foy and Rugolo worked in collaboration with ADF&G and other NOAA Fisheries scientists on crab management projects which were presented at the symposium. Siddeek et al. highlighted the primary differences between the new and old FMPs, such as the change in reported biomass currency from total mature biomass to mature male biomass and a change in the overfishing limit to include total removal from all fisheries instead of retained catch removals from the directed fishery. Jie et al. evaluated the stock assessment model for St. Matthew Island blue king crab. A catch-survey analysis was developed to include trawl survey, pot survey, and commercial catch data from 1978 to present. Multiple scenarios changing natural mortality and survey catchability were presented and evaluated.

In addition to the contributions of Shellfish Assessment Program to the symposium, other AFSC biologists were involved with eight presentations and posters ranging from density-dependent and independent factors controlling snow crab distributions in the EBS, estimating unobserved mortality rates of Bering Sea crabs due to encounters with trawls on the seafloor, historical perspective of Bristol

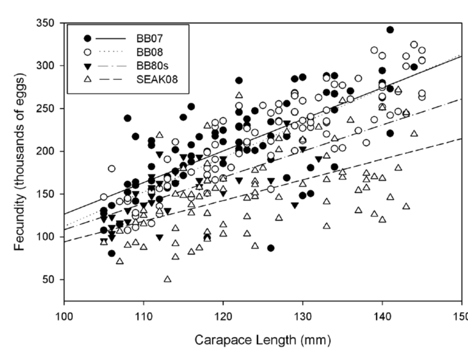


Figure 12. Fecundity with regression lines of 105–145 mm carapace length Alaskan red king crab (*Paralithodes camtschaticus*). BB07 = Bristol Bay 2007 summer collections ($R^2 = 0.51$), BB08 = Bristol Bay 2008 summer collections ($R^2 = 0.75$), BB80s = Bristol Bay 1982, 1983, 1985 summer collections ($R^2 = 0.49$), SEAK08 = southeastern Alaska 2008 summer collections ($R^2 = 0.29$).

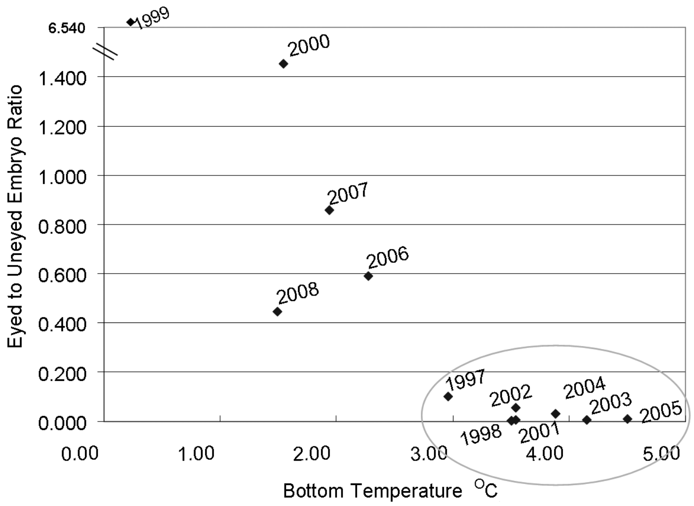


Figure 13. Ratio of eyed to uneyed embryos in female Bristol Bay red king crab (*Paralithodes camtschaticus*) with respect to bottom temperatures collected in early June on the eastern Bering Sea bottom trawl survey from 1998 to 2008.

Bay red king crab habitat and behavior, climate change and disease in marine ecosystems, bitter crab disease in Tanner and snow crabs, optimal nursery habitat for red king crab, and co-authoring the keynote address. The crab symposium was a great addition to the prestigious time series of Wakefield Symposiums and provided an opportunity for AFSC staff to interact and share research with colleagues throughout the world.

By Kathy Swiney

FISHERIES BEHAVORIAL ECOLOGY PROGRAM - NEWPORT LABORATORY

Emergent Biotic Structure Controls Juvenile Flatfish Distribution in Nursery Areas Off Kodiak Island, Alaska

Field studies around Kodiak, Alaska, reveal that age-0 juvenile Pacific halibut and northern rock sole (*Lepidopsetta polyxystra*) aggregate in shallow coastal waters (<50m) for their first summer, where they are closely associated with seafloor characterized by sparse to moderate coverage by ampharetid polychaete worm tubes. During the summer of 2008 the ampharetid polychaete worm *Sabellides sibirica* was more common at the Pillar Creek Cove study site than during any of the 8 years this site has been monitored (Fig. 14). This allowed for the testing of specific hypotheses regarding how juvenile flatfish interact with this worm tube habitat.

We had hypothesized that while attracted to areas of bottom covered by sparse or patch worm tubes, juvenile flatfish avoid dense worm 'turf', because it interferes with their first line of defense against predation; namely burial. To test this hypothesis, divers placed juvenile northern rock sole into microcosms over bare sand seafloor or seafloor covered by dense worm turf (Fig. 15). In sand treatments fish immediately buried into the bottom. In contrast, on worm bottom fish moved around, making repeated, but unsuccessful burial attempts (Fig. 16). After 5 minutes, fish on sand periodically emerged and moved about, but continued to bury at will. On worm turf bottom, fish continued to move about making unsuccessful burial attempts.

Fish distribution at Pillar Creek Cove was tightly associated with worm tube cover. The worm tubes formed a continuous turf from depths of 21 – 30 m (Fig. 17 top). Video from our towed camera sled revealed that age-0 flatfish density increased with depth, with the highest density at the edge of the worm turf, where the worm tubes were patchy (Fig. 17 middle). However, age-0 flatfish were nearly absent from bottom where worm tubes formed a dense turf. Importantly, fish were also infrequent along the outer (deeper) patch edge of the worm turf.

We had hypothesized that aggregation of fish in areas of sparse/patchy worm tube cover was attributable to 1) lower predation intensity, and/or 2) more or better quality forage base in this habitat. We tested this first hypothesis by tethering juvenile flatfish over a range of depths from 4 to 47 m. Predation mortality of tethered fish increased with depth from 4 to 16 m (Fig. 17 bottom), but then declined significantly at 21 m; the area of sparse worm tubes along the turf edge where juvenile flatfish density was highest. This suggests that reduced predation risk in the vicinity of sparse/patchy worm tube cover may partially explain juvenile flatfish preference for this habitat. We are also exploring the nonmutually exclusive hypothesis that juveniles are attracted to this habitat by its associated forage base. During July through September, we took both benthic grab samples and fish for stomach analysis across a range of depths to determine habitat specific prey availability and diets of juvenile flatfish. These samples are currently being analyzed at the University of Alaska Fairbanks (benthic samples) by Stephen Jewett and at the Kodiak Fisheries Research Center (stomachs) by Brian Knoth.

It is particularly noteworthy that the prevalence of this worm tube habitat varies greatly from year to year, and in some years, is completely absent from our study sites. Additional studies are ongoing to elucidate the role this conspicuous habitat feature plays in controlling the quality of shallow water nursery embayment for juvenile flatfish utilizing the nearshore waters of the Gulf of Alaska, as well as examining how natural anthropogenic disturbance influences this habitat.

By Clifford H. Ryer

Figure 14. During summer 2008, the polychaete *Sabellides sibirica* formed a dense turf between depths of 21 and 30 m at Pillar Creek Cove. Photo courtesy of Stephen Jewett, University of Alaska Fairbanks.

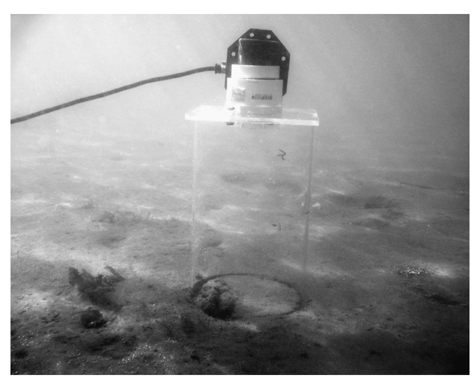


Figure 15. Acrylic microcosm inserted into substrate by divers allowed video monitoring of juvenile flatfish behavior on bare sand and worm turf seafloor. Fish were introduced to the microcosm through a port on the top of the cylinder and monitored for approximately 1 hr.

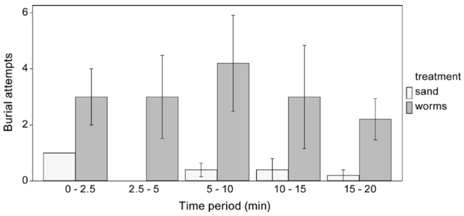


Figure 16. Burial attempts by juvenile northern rock sole on sand and worm turf seafloor. Along the x-axis, time is divided into 2.5 min intervals.

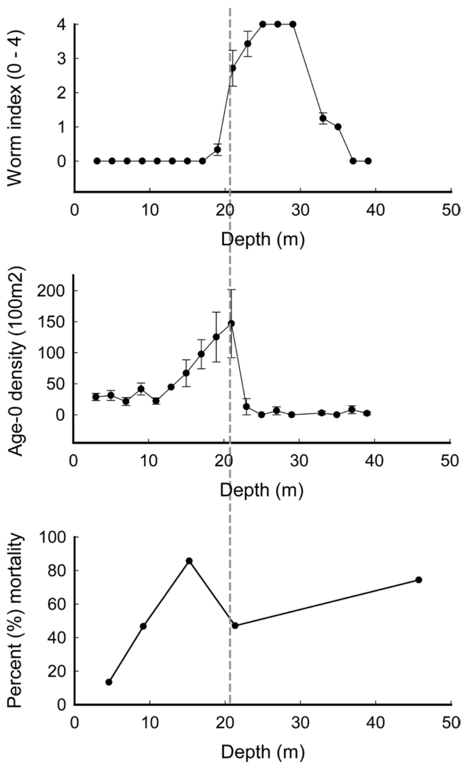


Figure 17. *Top,* abundance of worm tubes across depth at Pillar Creek Cove, as indicated by a qualitative abundance index acquired through camera sled video footage (0 – absent, 1 – sparse, 2 – moderate/patchy, 3 - dense/patchy, 4 – continuous turf). *Middle,* abundance of age-0 flatfish (predominantly northern rock sole) across depth. *Bottom,* percent (%) mortality of juvenile flatfish tethered at various depths over a 15 min deployment. N > 500 juvenile flatfish tethered

Resource Ecology & Fisheries Management (REFM) Division

RESOURCE ECOLOGY & ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

During the first quarter of 2009, fisheries observers collected 556 stomach samples from the eastern Bering Sea. In the laboratory, Resource Ecology & Ecosystem Modeling (REEM) Program staff analyzed 1,704 stomach samples from seven predator species. In total, 3,399 records were added to the REEM food habits database.

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

Alaska Marine Science Symposium Presentations

RESOURCE ECOLOGY

Todd TenBrink attended the Alaska Marine Science Symposium in Anchorage, Alaska, in January to present a poster detailing studies of age, growth, maturity, and food habits of five sculpins—plain sculpin (*Myoxocephalus jaok),* great sculpin (*M. polyacanthocephalus),* warty sculpin (*M. verrucosus),* yellow Irish lord (*Hemilepidotus jordani),* and bigmouth sculpin (*Hemitripterus bolini*)—in the eastern Bering Sea and Aleutian Islands. Filling life history data gaps will aid in assessing sculpin stocks and help to better understand their ecological role in these regions. The break and burn method for otoliths was used to age all species, with the exception of the yellow Irish lord, which was aged using thin sectioning. Maximum ages (years) are as follows: yellow Irish lord (28), bigmouth sculpin (20), warty sculpin (18), great sculpin (17), and plain sculpin (16). In each species, sex-specific von Bertalanffy growth curves were derived and were found to be statistically different. This study was the first to report on the ageing of the warty and bigmouth sculpins, and estimated maximum ages for the yellow Irish lord, great sculpin, and plain sculpin are the highest reported. Maturation was investigated based on histological methods, and analyses are being conducted for great sculpin, yellow Irish lord, and bigmouth sculpin. Length and age at 50% maturity for the yellow Irish lord for the eastern Bering Sea and Aleutian Islands was estimated to be 26.1 cm (3.4 years) and 28.9 cm (5.0 years), respectively. Maturity estimates were also reported for the great and bigmouth sculpins in the eastern Bering Sea.

MULTISPECIES MODELING

Stephani Zador attended the Alaska Marine Science Symposium and presented a poster focusing on potential distributional shifts in overlap between arrowtooth flounder and walleye pollock in the Bering Sea. The work identified physical and biological habitat characteristics that are correlated with arrowtooth flounder biomass trends sampled at individual trawl stations and found that small-scale regions within the eastern Bering Sea shelf have contributed unequally to the overall rapid increase in abundance of arrowtooth flounder. Applying the hierarchical k-medoids clustering technique to arrowtooth catch-per-unit-effort data revealed four distinct spatial groups showing stable, increasing, and variable trends. Catch rates in high-density areas near the shelf break have remained stable since the early 1990s while catch rates have increased to the northwest and east. Annual changes in range expansion and contraction are negatively correlated with the extent of the cold water pool on the Bering Sea shelf. Age-1 and age-2 pollock comprise the majority of arrowtooth diets in all areas, but higher rates of nonempty stomachs in the northwest region indicate that predatory impacts on pollock may be higher there. This analysis will provide information about the potential for arrowtooth flounder to further increase their distribution and abundance in the Bering Sea and help to predict future responses to climate and fisheries management actions.

ECOSYSTEM MODELING

Ivonne Ortiz attended the Alaska Marine Science Symposium and presented a poster describing FEAST (Forage-Euphausiid Abundance in Space and Time), a multispecies bioenergetics model for forage and predatory fish species linked to NPZ (Nutrient-Phytoplankton-Zooplankton) and ROMS (Regional Ocean Modeling System) for the northeast Pacific and Bering Sea at a 10-km resolution that is part of the Bering Sea Integrated Research

Program (BSIERP). The FEAST models includes nine fish species (walleye pollock, Pacific cod, arrowtooth flounder, salmon, capelin, herring, eulachon, Pacific sand lance and myctophids) which have a two-way interaction with the seven zooplankton groups in the NPZ model (small/large microzooplankton, small/large copepods, euphausiids, jellyfish, and benthic infauna). Additionally, temperature and advection from the ROMS model are used in the bioenergetics and movement components. The operating hypothesis in FEAST is that forage fish and macrozooplankton (e.g., euphausiids) are tightly coupled in a two-way interaction, and the dynamics of this interaction under different climate scenarios is a strong structuring element for the ecosystem as a whole. For example, variation in late summer prey supply may affect the fall diet transition of predatory fish switching from plankton to fish, affecting the year-class strength of multiple species and overall availability of forage species within the ecosystem. Retrospective data analysis provides some basic parameters and initial conditions for FEAST. Data for feeding patterns is from the Food Habits database maintained by the REEM Program. FEAST will also make extensive use of data collected by other BSIERP projects, particularly those related to acoustic surveys, fish distribution, and functional foraging responses. FEAST itself will ultimately be incorporated into economic and spatial fishery predictions, as well as into management strategy evaluations which are also part of BSIERP.

By Todd TenBrink, Stephani Zador, Ivonne Ortiz, and Kerim Aydin

Seabird Coordinated Studies

The Seabird Coordinated Studies group worked on several projects this quarter. The primary project was to upgrade the seabird presentations for the North Pacific fishery observer 3-week training and 4-day briefing sessions. Shannon Fitzgerald worked closely with Kristy Lewis of the Fishery Monitoring and Analysis (FMA) Division to revise the presentations and provide them to all observer training and briefing sessions held in Seattle. Lewis took on briefing and training duties as well and coordinated closely with the Observer Training Center in Anchorage. In another project, the FMA Division is providing a much needed service in making database changes to capture what had been in the past “ad hoc” information on seabirds that observers recorded. This information encompasses additional mortalities from third wires or trawl warps, bird storms, sightings of short-tailed albatross, and other seabird events at sea that go beyond the normal sampling routine. In a separate project, Dr. Ann Edwards is working with the REEM Program to assist on the production of a NOAA Technical Memorandum that reports seabird bycatch from 1993 through 2006, based on the analysis completed by Michael Perez of NMML before he retired in 2007.

By Shannon Fitzgerald

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

Measuring Harvesting Productivity of Pollock Catcher-Processors

Traditional productivity measures have been much less prevalent in the fisheries economics literature than other measures of economic and biological performance. It has been increasingly recognized, however, that modeling and measuring fisheries’ production relationships is central to understanding and ultimately correcting the repercussions of environmental impacts on fisheries and poorly designed regulations. In this study, authors Ron Felthoven from the Economics & Social Sciences Research (ESSR) Program, and Catherine Morrison Paul and Marcelo Torres from the University of California, Davis, use a transformation function production model to estimate productivity and its components for catcher-processors operating in the Bering Sea and Aleutian Islands pollock fishery, before and after the introduction of the American Fisheries Act. Among other things, the Act introduced a cooperative system that grants exclusive harvesting privileges and allows quota exchange. These aspects of the management system have led to innovations in fishing and targeting strategies not viable under the former Olympic-style fishery.

The model of the catcher-processors developed for this study recognizes the roles of externalities from pollock harvesting by incorporating data on climate, bycatch, and fish biomass. The results suggest that harvesting productivity has been increasing over time, that many productive contributions and interactions of climate, bycatch, and fishing strategies are statistically significant, and that regulatory changes have had both direct and indirect impacts on catch patterns and productivity. A paper on the subject titled “Measuring Productivity Change and its Components for Fisheries: The Case of the Alaskan Pollock Fishery, 1994-2002” was published in a recent volume of the journal *Natural Resource Modeling*.

By Ron Felthoven

Alaska Fishery CGE Model Completed

To avoid the limitations of fixed-price models, a state-level computable general equilibrium (CGE) model for Alaska fisheries was developed. The model has 18 industries and 17 commodities. Using the model, we investigated the effects of three stylized exogenous shocks—1) a reduction in pollock total allowable catch (TAC), 2) an increase in fuel price, and 3) a reduction in world demand for Alaska seafood—on endogenous variables such as output, employment, value added, commodity prices, and factor prices. Changes in household welfare were also estimated. To model different assumptions on intersectoral and interregional movement of factors of production, we developed two different versions of the CGE model: Keynesian and neoclassical. There are very few CGE studies of fisheries in the literature. Unlike these previous CGE studies of fisheries, this study is unique in that it estimates effects of both supply-side shocks (i.e., change in TAC and change in price of a major productive input, fuel cost) and a demand-side shock (change in the rest of world demand for Alaska seafood). Some of the findings from this study are as follows.

First, this study shows that the CGE model has the capability to address the impact on regional fisheries of various scenarios affecting either the supply-side or demand-side. Second, impacts estimated in Keynesian CGE variant are generally larger than those from the neoclassical CGE. This is because in the neoclassical CGE all labor released from seafood industries is absorbed into nonseafood industries while in the Keynesian CGE the released labor is not employed in the region. Third, impacts of higher fuel price are much larger on average in percentage terms for seafood industries than for nonseafood industries because the average share of revenues expended as fuel costs by the seafood industries is higher than the average share of revenue in most non-seafood industries. Finally, welfare loss is greatest for high income households under all experiments and in both CGE model versions due to their relatively greater participation in factor markets.

The results from this study were summarized in a manuscript which will be submitted to a scientific journal. A logical extension of the approach used in this study is to develop an interregional or multiregional CGE model (MRCGE) for the Alaskan economy and its seafood industries. Much of the primary and intermediate inputs used in Alaska industries (including seafood harvesting and processing) are imported, especially from the west coast states of Washington and Oregon. Using an MRCGE, it would be possible to trace in much greater detail the effects of shocks such as those considered in this study not only on Alaska, but also on the regional economies that supply goods and services to the Alaska seafood industry.

By Chang Seung and Edward Waters

Amendment 80 Economic Data Report

ESSR Program staff completed preparations for administration of the annual economic data reporting (EDR) requirement in the Amendment 80 groundfish fishery. Data elements collected in the EDR form include cost, revenue, effort, and capacity measurements, and were specified for collection in the Amendment 80 implementing regulations.

Focus groups with Amendment 80 vessel owners were conducted during January and February 2009 to develop definitional and instructional text and revise the EDR form. These revisions will improve the consistency of interpretation by EDR submitters and minimize measurement error due to questionnaire effects. In collaboration with Pacific States Marine Fisheries Commission (PSMFC), an accounting firm was selected to perform data validation audits. Staff also collaborated with PSMFC and Alaska Fisheries Information Network (AKFIN) personnel to design and implement electronic data entry forms with automated error checking and a relational database design that will be populated directly from electronic files emailed by submitters, largely eliminating manual data entry. In addition to minimizing data quality errors, these steps will facilitate integration with other fisheries databases (e.g., CFEC e-landings and Commercial Operators Annual Report data) for rapid identification of outliers and other data quality concerns to address in the data validation audit. Insights gained by ESSRP staff through the Bering Sea-Aleutian Islands (BSAI) Crab EDR design, administration, and data quality assessment process were important in improving the Amendment 80 EDR design process, from eliciting more useful input from focus group participants to anticipating data user requirements in database design. EDR submissions for 2008 calendar year fishing and processing operations are due from permit holders on 1 June 2009.

By Brian Garber-Yonts

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

Arctic Fishery Management Plan

In February 2009, the North Pacific Fishery Management Council adopted a new fishery management plan (FMP) for the Alaskan Arctic. The Arctic FMP covers all U.S. Federal waters north of the Bering Strait and includes large portions of the Chukchi and Beaufort Seas (Fig. 1). If approved by the Secretary of Commerce, the FMP would effectively prohibit all commercial fishing in this Arctic management area. Scientists from the Status of Stocks & Multispecies Assessment (SSMA) and REEM Programs provided essential scientific advice to the Council and Alaska Region staff who drafted the FMP.

Meeting the requirements of the NMFS National Standard guidelines for FMPs was particularly challenging in the Arctic. Plans must specify reference points such as maximum sustainable yield (MSY) for target species, and include background data on the ecosystem. The small amount of fisheries research that has been conducted in the U.S. Arctic north of Bering Strait has been infrequent and rarely of the type that allows for quantitative assessment of fish stocks. A University of Alaska Fairbanks (UAF) survey conducted in 1990 provided the best data regarding the density of fish and crab stocks in the northeastern Chukchi Sea. Fortunately, in August 2008 REFM scientists conducted a survey in the Beaufort Sea that provided density estimates for species there. The densities were multiplied by the spatial area the surveys covered to provide estimates of biomass. Because the surveys covered only a portion of the Arctic management area (Fig. 1), those biomass values are probably underestimates.

The other main challenge was creating a fishery management plan for an area where no commercial fisheries currently exist. This seeming paradox posed legal difficulties but was solved using an elegant mathematical formula to identify three target fisheries that could be commercially viable: snow crab, Arctic cod, and saffron cod. For each target species, MSY was calculated and the optimum yield (OY) was specified by reducing MSY based on scientific uncertainty as well as economic and ecological considerations. Because the level of uncertainty in the Arctic is very high (due to the scarcity of data), because fishing there is very expensive, and because all three species are important ecosystem components, the OY was set at essentially zero. A small amount of catch is allowed to meet subsistence needs. The FMP specifies a number of requirements including the collection of data sufficient for effective management and an impacts analysis, that need to be met before the Council would considers opening a target fishery.

By Olav Ormseth

DisMELS: A Dispersal Model for Early Life History Stages

Juveniles of many flatfish species have distinct habitat requirements (such as sediment grain size) and thus use specific areas as “nurseries.” For some species, adult spawning grounds are substantially removed from potential juvenile nurseries. Consequently, the dispersal pathways of eggs and larvae via oceanographic currents are critical factors in the process of recruitment for many flatfish species, where “recruitment” is generally the number of individuals that survive the dispersive pelagic stage and reach some age as juveniles, such as age 1. In 2002, Tom Wilderbuer, Jim Ingraham and other SSMA scientists found that annual recruitment of several flatfish species in the eastern Bering Sea was fairly well correlated with the final location of a drifter simulated using OSCURS, a simple surface wind drift current model. Their findings indicated that recruitment was *potentially* high for years in which the simu-

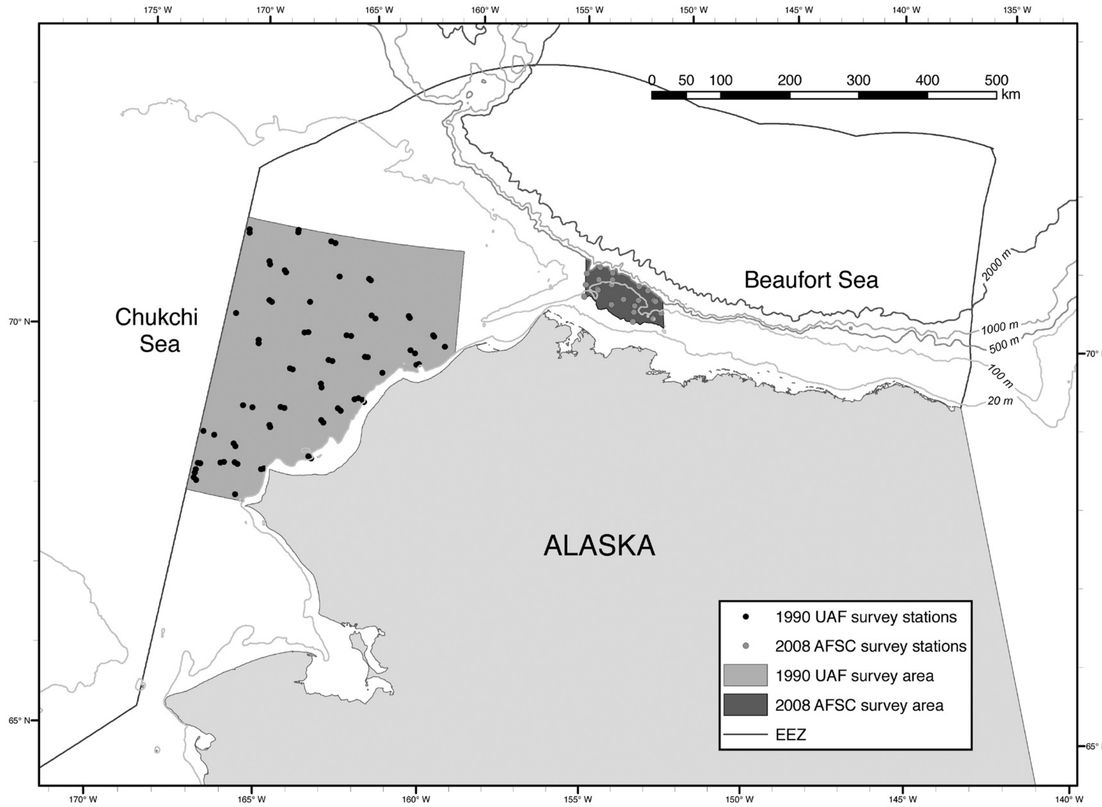


Figure 1. Map of the U.S. Arctic north of Bering Strait showing the boundaries of the Arctic Management Area and the spatial extent of the two surveys used to produce biomass estimates and reference points for the Arctic fisheries management plan.

lated drifter moved inshore from its release location at lat. 56°N, long. 165°W (near the edge of the continental shelf) into shallow water but that recruitment was always low for years in which the simulated drifter moved off the continental shelf into deep water. Subsequently, the OSCURS model has been used to make an annual *qualitative* prediction of flatfish recruitment strength. This prediction is included in the Ecosystems Considerations Report provided by the AFSC to the North Pacific Fishery Management Council as part of its annual stock assessment process.

Because the OSCURS-based recruitment prediction is only qualitative in nature, it has not been incorporated directly into any of the stock assessment models used to assess flatfish stocks. Generally, these stock assessment models make their own estimates of annual recruitment strength by determining the number of individuals that are needed to recruit at age *a* in year *x* to end up with an observed number of individuals of age *y* in year *x*+*y*-a, given assumptions about natural and fishing mortality in intervening years. An independent, *quantitative* estimate of recruitment strength for the assessment models could greatly improve these models' estimates of stock size and allowable catch, as well as recruitment.

In an effort to provide quantitative predictions for flatfish recruitment that can be incorporated directly into stock assessment models, William Stockhausen in REFM is developing DisMELS, a coupled individual-based biophysical dispersal model for early life history stages. While OSCURS simulates the tracks of passive drifters that are confined to the ocean surface, the individual eggs and larvae that DisMELS simulates are not confined to the ocean's surface because it uses 3-dimensional (3-D) current fields from a 3-D oceanographic model to drive advective transport. It turns out that the depth at which individuals are tracked can make a big difference in where they end up.

The simulated individuals in DisMELS can also incorporate important aspects of the behavior of real eggs and larvae. For example, Janet Duffy-Anderson and other scientists in the joint AFSC-Pacific Marine Environmental Laboratory (PMEL) eco-FOCI research program have shown that the eggs and larvae of some flatfish species are concentrated below the surface, not at the surface (as modeled by OSCURS). Additionally, while eggs and the youngest larvae may change depth slowly (over the course of many days) as they develop, older larvae may migrate vertically between depth zones on a daily basis. In DisMELS, it is possible to capture these ontogenetic and diel changes in depth as part of the "behavior" of simulated individuals. In addition, DisMELS can easily track the dispersal of thousands of simulated individuals over time (Fig. 2), thus leading to a quantitative prediction of recruitment strength (as the fraction of individuals "spawned" that arrive at nursery sites when they are capable of leaving the plankton for a primarily benthic existence). This quantitative prediction of recruitment strength can then be fed into a stock assessment model to improve its own estimate of recruitment.

DisMELS consists of a series of graphical user interfaces (Fig. 2) that allow users to easily set up and run individual-based models, as well as an application programming interface (API) that allows users to create their own stage-based behavioral models for use in the dispersal simulations. Currently, three relatively simple life stages have been defined: an adult stage, a pelagic stage, and a "settler" stage. Ontogenetic

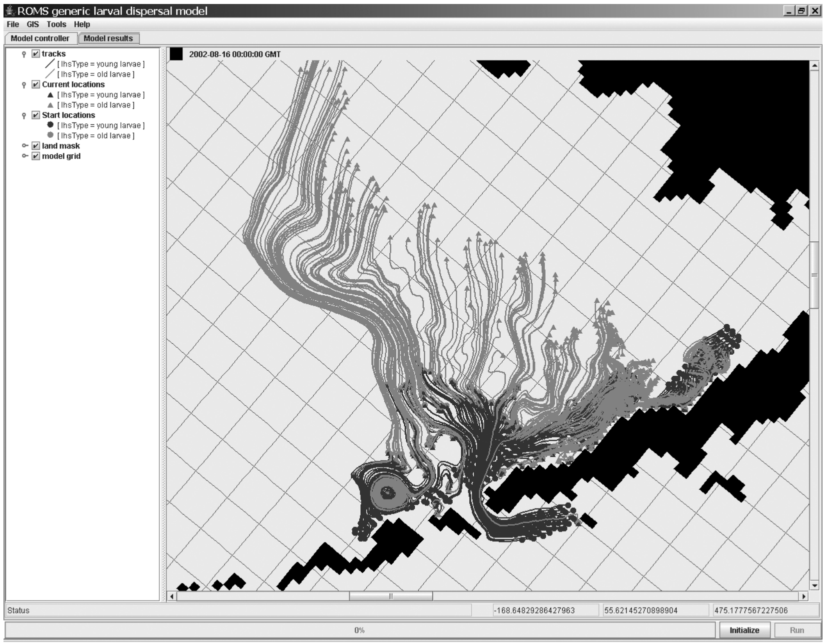


Figure 2. A screenshot of the DisMELS graphical user interface after running a dispersal simulation, showing the "spaghetti" tracks of individual simulated larvae. Light gray squares encompass 5x5 grid cells (~10 km on a side) used in the NEP ROMS oceanographic model; black areas signify land. Several hundred northern rock sole "early stage larvae" were released from five "spawning areas" (dark gray dots indicate release positions) along the Alaska Peninsula and tracked for 60 days. Upon reaching ~8mm size, "early stage larvae" (tracks in dark gray) become "late stage larvae" (tracks in medium gray), which undergo diel vertical migrations between 10-20m depth (nighttime) and 30-40 m depth (daytime). Medium gray triangles indicate positions of "late stage larvae" after 60 days.

changes in behavior within a stage can be incorporated by "daisy-chaining" several sub-stages together (with different parameter values for successive stages) and setting the conditions under which individuals change from one sub-stage to the next. For adult stages, spawning season, spawning frequency, fecundity (number of individuals spawned), and spawned life stage (e.g., egg stages with different development rates) can be specified. For pelagic stages (i.e., eggs and larvae), preferred daytime and nighttime depth ranges, vertical swimming speed, vertical diffusion, growth and mortality rates, and stage duration can be specified. The settler stage has behavior and parameters similar to that of the pelagic stage, but the user can also specify the characteristics (as a depth range) for suitable nursery habitat; when a settler reaches suitable nursery habitat, it leaves the plankton, "settles" to the benthos, and is counted as a successful recruit. Settlers that do not reach suitable nursery habitat within a user-specified time interval are counted as dead.

Time series of precomputed 3-D oceanographic currents, temperature and salinity fields are required to drive DisMELS. At present, output from the ROMS (Regional Oceanographic Modeling System) model for the northeast Pacific (NEP ROMS), as well as other ROMS models, can be used to drive dispersal simulations.

As an initial application, Stockhausen, Wilderbuer, Duffy-Anderson, and Al Hermann (Joint Institute for the Study of the Atmosphere and Ocean/PMEL) are using DisMELS to develop recruitment predictions for northern rock sole and Alaska plaice in the eastern Bering Sea.

By William Stockhausen

Stock Structure Symposium

A symposium entitled "The role of stock structure in the management of commercial fisheries" was held at the February 2009 meeting of the Scientific and Statistical Committee (SSC) of the North Pacific Fishery Management Council (NPFMC). The meeting was motivated by recent discussions in NPFMC Groundfish Plan Team and SSC meetings concerning stock structure for a number of Alaskan fish species. Scientists from the AFSC, Northwest Fisheries Science Center, University of Washington, and University of Alaska presented information on techniques for incorporating spatial complexity in stock assessments, the types of information used to infer stock structure, and local adaption of fish populations to their environment. Information on spatial population structure was presented for Alaska populations of Atka mackerel, Pacific cod, and several rockfish species. As a result of the symposium, a working group was created to develop guidelines to assist stock assessment authors, plan teams, and the SSC in determining when subregional fishing level recommendations for a species might be appropriate.

By Paul Spencer

Incorporating Stock Reproductive Potential into Stock Assessments

On 13-15 January 2009, Paul Spencer (SSMA Program) participated in a working group focused on incorporating stock reproductive potential (the capacity of a fish stock to produce eggs and larvae) into stock assessments. The working group met in Vigo, Spain, and was funded by the European Cooperation in the field of Scientific and Technical Research (COST). The working group is one of three working groups that comprise the "Fish Reproduction and Fisheries" (FRESH) project; the other two working groups focus on 1) identifying underlying causes of variation in stock reproductive potential, and 2) standardizing methods for sampling and estimating stock reproductive potential. The aim of the FRESH project is to create a network in which stock assessment scientists and biologists studying fish reproduction can work together to address these three topics.

The working group was titled "Linking biology and assessment: Improving stock assessment through implementation of stock reproductive potential." The format of the working group meetings was to hold workshops and "training schools" where specific mechanisms for incorporating reproductive biology into assessments were presented. At the Vigo meeting, Dr. Richard Hillary (Imperial College) led a workshop on fitting stock-recruitment relationships with Bayesian hierarchical models. Additionally, Dr. Iago Mosqueira (Centre for Environment, Fisheries, and Aquaculture Science) led a tutorial on the Fisheries Library in R (FLR) software.

Paul Spencer presented a review and progress report of maternal effects (influence of a spawner's age, size, or condition upon egg or larval quality) modeling and field research in the North Pacific. Simulation modeling conducted by Paul Spencer indicates that when a maternal effect in larval survival exists but is not recognized in an assessment model, biases in estimated productivity can be small at low and intermediate levels of fishing mortality and can increase at larger values of fishing mortality. Additionally, results from field research on Pacific cod egg quality, conducted by Olav Ormseth (SSMA Program), and Gulf of Alaska Pacific ocean perch larval quality, conducted by Dr. Scott Heppell (Oregon State University), were presented.

By Paul Spencer

AGE & GROWTH PROGRAM

New and Improved Age Reading Demonstration (ARD) Web Site

The Age and Growth Program has updated its Age Reading Demonstration (ARD) interactive Web site to include many new features. As with the original version, visitors are able to place annulus marks on otolith images and then automatically mark the otolith image with marks from an experienced age reader. The new version takes advantage of the graphical interactivity of Adobe Flash and allows users to zoom in and out of images, drag a movable scale bar around the image, view ageing statistics, and navigate through image thumbnails. ARD presents otoliths from various species and of varying levels of ageing difficulty, which demonstrates that otoliths from different species often require completely different ageing strategies, and that otoliths from even an easy species can present difficult challenges.

The purpose of the ARD Web site is not to "teach" age reading. An age reader typically must view thousands of otoliths through a binocular microscope in order to understand growth patterns before acquiring proficiency on a species. Instead, the purpose of the ARD Web site is to give scientists and the general public a better appreciation of how difficult age reading really is. A future goal will be to allow the comparison of ageing criteria, between labs, on a real-time basis using similar software. The ARD Web site can be viewed at: http://www.afsc.noaa.gov/refm/age/interactive.htm.

By Jon Short

Estimated production figures for the period from 1 January through 31 March 2009. Total production figures were 6,386, with 1,586 test ages and 80 examined and determined to be unageable.

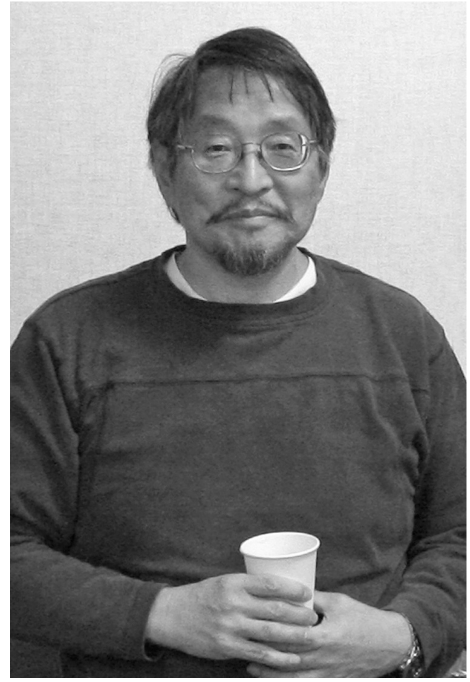
Species	Specimens Aged
Flathead sole	470
Rex sole	993
Northern rock sole	263
Yellowfin sole	477
Greenland turbot	240
Pacific cod	573
Walleye pollock	1,797
Pacific ocean perch	341
Northern rockfish	847
Dusky rockfish	293
Quillback rockfish	52
Bigmouth sculpin	40

Dan Kimura Retires After 25 Years With the REFM Division

Dan Kimura, Age and Growth Program leader, retired in January 2009 with over 25 years of Federal service. Dan earned a bachelor of science degree in mathematics from the University of Washington (UW) in 1967. He worked briefly for the Boeing Company and returned to the UW where he earned his doctorate in biomathematics in 1972. His dissertation was on Fournier methods for censored data. Following the completion of his Ph.D., Dan worked at the UW Department of Oceanography for several years.

Dan's career in fisheries began in 1974 at what was then known as the Washington State Department of Fisheries, where he applied mathematical models in a variety of fish population assessments. Dan's research included stock reduction analysis, statistical assessment of fish age-length keys, applying the von Bertalanffy growth model, stock structure estimations from fish tagging experiments, quality control of fish age data, and numerous fish age validation studies. His early work using fish age-length keys in stock assessments was fundamental and still is used routinely today.

In March 1983 Dan joined the AFSC's REFM Division as a mathematical statistician in the Status of Stocks Program. One of



Dan Kimura

his early assignments was the stock assessment for Aleutian Islands Atka mackerel. The age data generated for this assessment appeared uncertain. As a result, Dan critically questioned the staff of the Age and Growth Program about the age determination practices for Atka mackerel. At the time, he did not know that he would eventually become the head of that program and help guide valuable research that would prove the unique methods correct.

Dan was appointed leader of the Age and Growth Program in 1987. During the 22 years of his tenure, the Age and Growth Program expanded its reputation of providing high-quality fish age data for stock assessments, as well as a first-class research lab on fish age validation. His guidance towards better age precision analysis, data management, documentation of ageing criteria, and publications on fish ageing studies has improved fish ageing science. He represented the Age and Growth Program at three International Fish Otolith Research and Application Symposiums. He inspired numerous research projects using natural radionuclides, atomic bomb produced radiocarbon, and other fish age validation methods. During his career Dan published an impressive 35 research papers, and 15 more that he coauthored

Dan's friends and colleagues at the Center wish him all the very best in retirement!

By Craig Kastelle