AUKE BAY LABORATORIES

MARINE SALMON INTERACTIONS

Record Snowfall at Little Port Walter

The winter of 2006-07 at Little Port Walter (LPW) Field Station was the snowiest on record. The winter saw 4 days of snowfalls greater than 2 feet and 1 day of almost 4.5 feet. Total snowfall (measured once daily) through 12 April 2007 was 268 inches, almost 30 inches more than the next highest snowfall recorded in 1973-74. The burden of dealing with all of that snow fell to station staff Pat Malecha, Dan Koenig, and Andy Gray who shoveled snow throughout the night on more than one occasion to keep floats from sinking and maintain the integrity of over 90 populations of Chinook salmon, steelhead trout, and rockfish used in LPW's many research projects. All projects came through the winter in good condition, although some aspects of the station infrastructure were damaged. Overall costs, however, were relatively minor, thanks primarily to the hard work of the staff.

The unusual snowpack (and resulting cold water temperatures) also has resulted in some unusual fish behavior this spring. The pink salmon, coho salmon, and steelhead smolt outmigrations from Sashin Creek have been unusually late. Pink salmon fry were still emigrating in late June (late May normally is very late); peak counts for coho smolts are at least 3 weeks later than normal; and steelhead smolts are still well below peak numbers normally seen in mid-June. It is quite likely that this late outmigration will result in extremely poor marine survival for the cohorts of these species when they return (2008 for pink and coho; 2009-10 for steelhead).

Provided by Frank Thrower

HABITAT ASSESSMENT & MARINE CHEMISTRY PROGRAM

Identifying Regional Variation in Harbor Seal Fatty Acid Signatures Using Analysis of Similarity (ANOSIM)

The abundance of harbor seal (*Phoca vitulina*) (Fig. 1) has declined in several regions of Alaska over the past 2-3 decades, while in other regions of the state the numbers are increasing. A decrease in prey quality and availability is a common hypothesis for explaining the decline in harbor seal populations (as well as other marine mammal populations in Alaska). In response to this trend, the Habitat and Marine Chemistry Program's Nutritional Ecology Laboratory at Auke Bay Laboratories is collaborating with the Alaska Department of Fish and Game (ADF&G) to investigate the relationship between regional trends and diets by analyzing the fatty acid (FA) composition of harbor seal blubber.

Inferring marine mammal diet from scat or stomach contents is logistically difficult and may yield biased results. Fatty acid patterns of prey species are reflected in the storage lipids of their predators, thus inferences can be made about an animal's diet and foraging ecology. Blubber samples taken from free-ranging animals can supply information about diet that is not limited to the last meal or dependent on the recovery and identification of undigested material or by durable prey pieces.

Figure 1. A young harbor seal ashore on a cobble beach. We will be examining dietary variation between age classes. Photo by John Moran.

We used analysis of similarity (ANOSIM) to compare blubber fatty acid signatures from 352 harbor seals in five regions of Alaska with differing population trends: Glacier Bay, where harbor seal numbers are decreasing rapidly (-14.7% 1992-2005); Prince William Sound, where numbers are stabilizing with an increasing short-term trend (-2.4% in 1990-2005; +9.0% in 2000-05); Southeast Alaska, which is stable (+0.6%, Sitka, in 1984-2005) or increasing (+5.0%, Ketchikan, in 1983-2003); Bristol Bay, which is increasing (+7.0% in 1995-2005); and Tugidak Island, which is increasing (+7.5%, Kodiak, 1993-2004). We found significant differences in fatty acid signatures between all five regions (Table 1). Prince William Sound and Glacier Bay were most similar (ANOSIM $R = 0.355$, $P < 0.001$) and both had decreasing population trends during years when blubber was collected (1997-2001). We found the greatest difference in fatty acid signatures

Table 1. ANOSIM R values for fatty acid signatures from five regions in Alaska: Glacier Bay (GB), Prince William Sound (PWS), Southeast Alaska (SE), Bristol Bay (BB), and Tugidak (Tug); p values in parenthesis. (R values range from -1 to 1, positive values indicate a difference between groups, if there is no difference R = 1, negative value indicate a greater difference within groups than between groups).

	BB	GB	PWS	SE
GB	0.568 (0.000)			
PWS	0.644 (0.000)	0.355 (0.000)		
SE	0.666 (0.000)	0.769 (0.000)	0.779 (0.000)	
TUG	0.526 (0.000)	0.820 (0.000)	0.837 (0.000)	0.590 (0.003)

when comparing Tugidak to Glacier Bay (ANOSIM R = 0.826, P < 0.001) and Tugidak to Prince William Sound (ANOSIM R = 0.837, P < 0.001). These regions had opposite population trends during the sampling period. Our analysis indicates that harbor seals from these five sites differ in diet composition, which supports the hypothesis that prey availability or quality may be influencing regional population trends.

We are continuing to investigate dietary variation within harbor seal populations by examining factors such as age, sex, and haul-out substrate (glacial ice versus land). As additional samples become available, we believe that this interagency effort will provide not only information on population trajectories but valuable insight in the feeding ecology of Alaska harbor seals.

By John Moran

Significance of Humpback Whale Predation on Over-Wintering Pacific Herring in Prince William Sound and Southern Lynn Canal

Two stocks of Pacific herring (*Clupea pallasii*), one in Prince William Sound (PWS) and the other in southern Lynn Canal, have been struggling in population numbers since 1982. To survive winter months when little prey is available, Pacific herring lower their energy requirements by seeking out bays and trenches with cooler water and little current. On these over-wintering grounds, herring form large, dense aggregations vulnerable to predation. The spatial and temporal consistency of these herring schools provides a predictable, high energy food resource for marine mammals such as humpback whales (*Megaptera novaeagliae*) (Fig. 2) and Steller sea lions (*Eumetopias jubatus*).

In Prince William Sound, herring have been classified as "not recovered" by the *Exxon Valdez* Oil Spill Trustee Council. The PWS herring fishery was thriving prior to the 1989 oil spill. The fishery closed from 1993 to 1997, opened for 2 years, and has remained closed since 1999. The fishery openings produced little in the way of catch. The Lynn Canal herring stock has failed to recover despite closure of the commercial herring fishery since 1982. Currently the Lynn Canal stock is being evaluated for listing under the Endangered Species Act. In both of these regions, humpback whales, often in signficant numbers, have been observed feeding heavily on herring during fall and winter.

The Habitat and Marine Chemistry Program, in cooperation with the University of Alaska Southeast, University of Alaska Fairbanks, and the ADF&G, is investigating humpback whale predation as a possible factor in the failed recovery of the two herring stocks. We are quantifying the impact of whale predation on recovery of these herring stocks through a series of semimonthly boat-based surveys and quarterly aerial surveys. Survey efforts include counting humpback whales and estimating abundance using photographic identification and determining prey through visual observations, trawling, and acoustics. The aerial surveys identify bays where there are focal groups of whales and are used to determine subsequent boat survey locations. We are estimating herring biomass using hydroacoustics during winter. Ultimately, we will use whale abundance estimates in a bioenergetic model to determine numbers of herring consumed (and energy content consumed). The estimated numbers of herring consumed will be incorporated into an age-structured model to assess the significance of whale predation on herring recovery.

To date we have completed our first winter of field work (2006-07) focusing on Sawmill Bay in PWS and southern Lynn Canal (herring sampling and assessments; whale photoidentification). Next year, we will repeat our sampling effort and will expand our efforts into Sitka Sound. Comparisons with Sitka Sound will provide a contrast of a healthy herring stock experiencing whale predation with the depleted stocks of Lynn Canal and PWS. Portions of this research are funded by two projects funded by the *Exxon Valdez* Trustee Council.

By John Moran

Figure 2. Euphausids dimple the water's surface attempting to escape from a humpback whale. A day later the same whale switched prey and fed on herring. Photo by John Moran.

MARINE ECOLOGY & STOCK ASSESSMENT PROGRAM

Deep-sea Coral Distribution and Habitat in the Aleutian Archipelago

Coral abundance in the Aleutian Islands far exceeds that reported for other high latitude areas of the world, and there are many endemic species. Research conducted by ABL staff in collaboration with the Alaska Department of Fish and Game and the University of Alaska Fairbanks on deep-sea coral distribution and habitat in the Aleutian Archipelago has provided an opportunity to further our knowledge about coral and sponge ecology, taxonomy, fishing gear impacts, importance to commercial species, and habitat requirements. The impetus for this study stemmed from the need to collect information for making fishery management decisions to protect coral and sponge habitats.

Multibeam habitat mapping of 17 sites covering 2,600 km^2 at depths of 30 – 3,800 m coupled with *in situ* observations to 2,950 m from 2003 to 2004 were used to collect biological information and develop predictive models that relate coral and sponge distribution to environmental characteristics. Habitats dominated by bedrock and cobble supported the highest densities of corals. Diversity of corals and sponges increased from deep to shallow water. For the predictive model, depth and slope were the most important explanatory variables. Models of coral and sponge presence/absence north of the Aleutian Islands Archipelago were more successful than models south of the archipelago. The most observed damage and disturbance to coral and sponge communities occurred at depths less than 800 m, which generally corresponded to the depth limit of the majority of fisheries that use bottom contact gear. There was a consistent positive relationship between damage and disturbance levels and intensity of bottom trawling, whereas results varied for other gear types. Some commercial fish and crab species aggregate in habitats where corals are abundant, making these habitats at risk to fishing gear impacts. Protective measures implemented in the Aleutian Islands include restricting bottom trawling to historically fished areas. While this protective measure may halt the expansion of bottom trawling to areas not fished, the conservation of coral and sponge habitat in fished areas is still of primary concern.

By Jon Heifetz

OCEAN CARRY CAPACITY PROGRAM

Influence of Spring Temperature on Juvenile Sockeye Salmon Distribution, Size, Condition, and Diet Along the Eastern Bering Sea Shelf

In order to determine possible factors influencing early marine growth and survival of juvenile sockeye salmon along the eastern Bering Sea continental shelf, interannual variations in distribution, size, indices of feeding and condition of juvenile Bristol Bay sockeye salmon *Oncorhynchus nerka* were assessed among fish collected in August – September (2000–03) during Bering–Aleutian Salmon International Surveys. Juvenile sockeye salmon were mainly distributed within the southern region of the eastern Bering Sea, south of 57˚0'N during 2000 and 2001 and farther offshore, south of 58˚0'N during 2002 and 2003. In general, juvenile sockeye salmon were significantly larger ($P < 0.05$) and had significantly higher indices of condition ($P < 0.05$) during 2002 and 2003 than during 2000 and 2001. The feed-

ing index was generally higher for age-1.0 sockeye salmon than age 2.0 during all years. Among-year comparisons suggested that Pacific sand lance (*Ammodytes hexapterus*) were important components of the juvenile sockeye salmon diet during 2000 and 2001 (20% to 50% of the mean wet mass) and age-0 pollock (*Theragra chalcogramma*) were important components during 2002 and 2003 (50% to 60% of the mean wet mass). Warmer sea temperatures during spring and summer of 2002 and 2003 likely increased productivity on the eastern Bering Sea shelf, enhancing juvenile sockeye salmon growth.

By Ed Farley

FISHERIES MONITORING & ANALYSIS (FMA) DIVISION

The FMA Division's Role in the Central Gulf of Alaska Rockfish Pilot Program

The Fisheries Monitoring and Analysis Division's (FMA) North Pacific Groundfish Observer Program, the NMFS Alaska Regional Office, and the fishing industry have worked together for several years to meet the challenges of new monitoring regulations brought about by changes in federal fisheries management in Alaska. This year the new Central Gulf of Alaska (GOA) Rockfish Pilot Program (Rockfish Pilot) is an example of a fishery transitioning from open access to a limited access management system. The Rockfish Pilot was originally tasked to NMFS by Congress as a 2-year project, but the newly reauthorized Magnuson-Stevens Fishery Conservation and Management Act expanded the Rockfish Pilot to 5 years. The first fishing under the Rockfish Pilot took place this spring.

In the past, the GOA rockfish fishery was a competitive open-access fishery constrained by species-specific quotas that, when met, closed the fishery for all participants. This open-access competition for fish led harvesters to increase the fishing capacity of their individual vessels and accelerated the pace of the fishery. Similarly, processors competed to increase their capacity to process fish. The rapid pace of competitive fishing provides disincentives to a focus on product quality which requires more time to produce. Additionally, fisheries management is more difficult due to the rapid pace of harvest and the challenges of monitoring catch and projecting a fishery closure within established limits.

The Rockfish Pilot provides harvesting and processing privileges for a specific complex of rockfish species. (Details of the specific allocations are complex and are available on the Web at http://www.fakr.noaa.gov/frules/71fr67210.pdf.) In general, this limited access program has potential to improve economic efficiencies by allowing market forces to influence the harvest and harvesting capacity rather than the open-access competitive arena. Similar improvements have been made in other North Pacific fisheries management programs, such as the Bering Sea pollock fishery allocated under the American Fisheries Act (AFA). The Bering Sea pollock fishery under the AFA has proved successful in providing economic opportunities for industry and viable processes for management while ending the highly competitive open-access style fishery for pollock. While such programs offer benefits to the participants, they offer monitoring challenges to NMFS.

The key challenge in limited access programs is to monitor quotas at a fine scale. NMFS monitors quotas at the individual vessel level or group cooperative level. For example, in the Rockfish Pilot each vessel is allocated a share of the available rockfish quota. Likewise, processors are allocated privileges to receive and process fish from vessels participating in this program. Vessels may form cooperatives with other vessels to deliver fish to a particular processor. Vessels not in a cooperative still have the opportunity to fish. In many cases, the information used to manage these fine-scale quotas comes from at-sea observers. This requires higher levels of observer coverage and improved ability to transmit data to NMFS quickly. To meet increased information needs, the participants have increased monitoring requirements.

Increased requirements in the Rockfish Pilot are:

1) Catcher vessel participants must have 100% observer coverage, a change from the usual 30% observer coverage. Catcher vessels are also required to have a vessel monitoring system (VMS) and a computer for observer data entry.

2) Processing facilities are required to have an observer for each 12-hour period that the facility receives a Rockfish Pilot delivery. Thus, the processor may receive fish from Rockfish Pilot vessels only during a 12-hour window each day, or the processor would need to have two observers assigned to the facility. A Rockfish Pilot observer cannot be assigned to more than one processor during a calendar day. This is a change from the usual coverage levels

Pacific ocean perch being delivered to a Kodiak processing plant. Photo by Rob Swanson.

based on processing volumes and which allows observers to cover two processing facilities on the same calendar day.

3) Catcher/Processors must have a VMS. Catcher/Processors are required to carry two observers, one of whom has a higher level of training. The vessel must provide a sample station and arrange for a pre-cruise briefing with FMA staff. These vessels already were required to have a computer for data entry and transmission.

In summary, industry must meet new equipment and observer coverage requirements while FMA must handle the increased volume of observers and the data they collect. The monitoring demands of programs like Rockfish Pilot increase the financial burden on industry and NMFS. We are working with industry to explore the feasibility of using video technology for some aspects of monitoring. To meet the immediate fishery needs, FMA is sending additional staff to Kodiak during the rockfish fishery to coordinate and facilitate observer data transmission and quality control.

The FMA provides a model of how industry and government can work together to facilitate data collection by observers to monitor fisheries managed through catch limits. As fisheries management systems continue to evolve toward limited access type programs, FMA, the NMFS Alaska Regional Office, and industry continue to work together to meet the increased information needs for fine-scale monitoring systems.

By Allison Barns

NATIONAL MARINE MAMMAL LABORATORY (NMML)

ALASKA ECOSYSTEMS PROGRAM

Steller Sea Lion Research

Permits authorizing most Steller sea lion research are still pending completion of NMFS' evaluation of permit applications, a Final Programmatic Environmental Impact Statement for Steller sea lion and northern fur seal research, and a Biological Opinion under the Endangered Species Act of the proposed research. However, some studies that involve observational work with little likelihood of disturbances are currently authorized. After a week of intense training in Seattle this May, seven seasonal and one full-time biologist from the Alaska Ecosystems Program (AEP) flew to Alaska to begin 2 months of fieldwork conducting observations of marked animals to estimate reproductive and survival rates. Three scientists were deployed on Ugamak Island in the eastern Aleutian Islands, and five were placed on Marmot Island in the Gulf of Alaska. In addition, on 9 June, AEP and Southwest Fisheries Science Center scientists began a biennial aerial survey to estimate the abundance of the western stock of Steller sea lions, using a NOAA de Havilland Twin Otter to survey all of the stock's rookeries and haulouts in the Gulf of Alaska and Aleutian Islands. Other fieldwork beginning in June included ship-based observations of marked animals to estimate vital rates in the Aleutian Islands, Bristol Bay, the Kodiak Archipelago, the Katmai Coast, the Barren Islands, and north along the Kenai Peninsula.

The revised Steller Sea Lion Recovery Plan was released by NMFS in May 2007 for another round of public and peer review; the review period will end in August 2007.

By Jim Thomason

Northern Fur Seal Update

Data are still being received from satellite telemetry tags deployed on adult female, pup, and juvenile northern fur seals during fieldwork conducted in October-November 2006 (see articles in the October-December 2006 and January-March 2007 issues of the AFSC *Quarterly Report*). Similar to previous years, the majority of the 19 tagged adult females headed south to the North Pacific

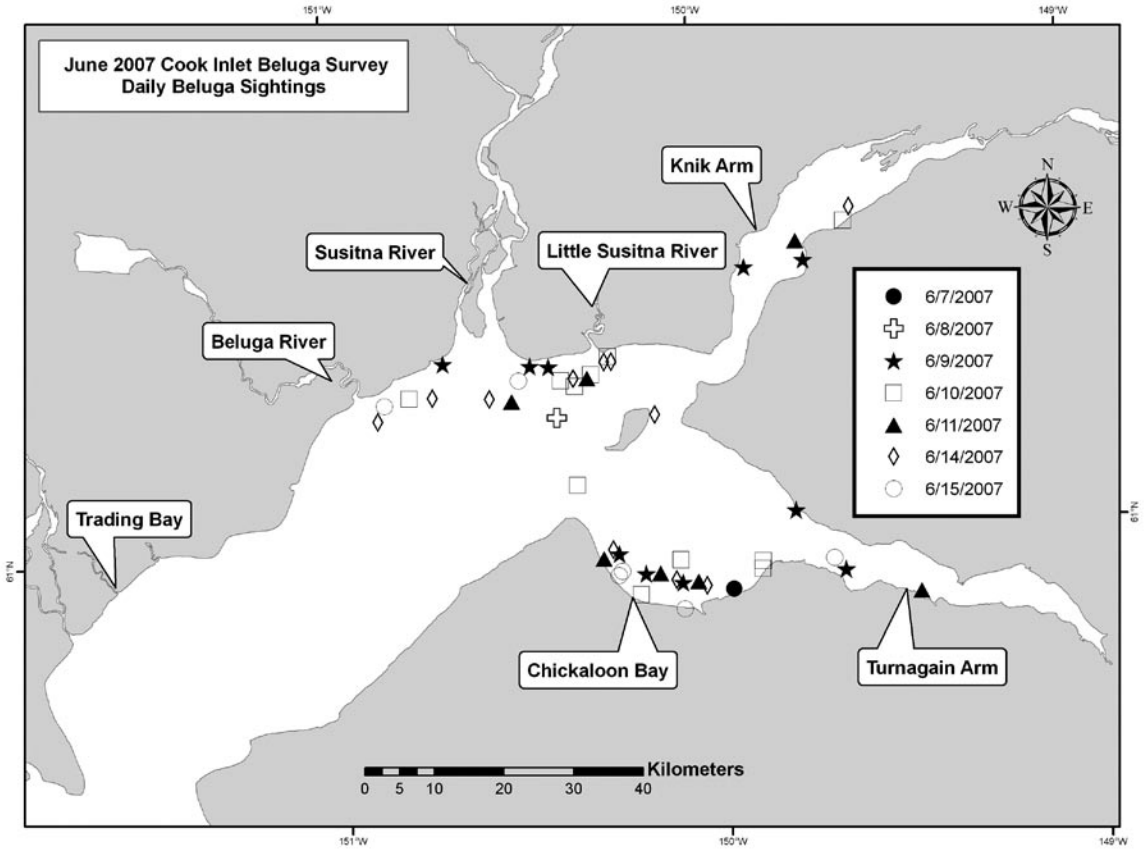

Figure 1. June 2007 daily beluga sightings in Cook Inlet. Each symbol represents a group of beluga whales.

Transition Zone. Although most of the tags deployed on females in fall 2006 had stopped transmitting by the end of March 2007, transmissions were still being received from one tagged female off the southern coast of Vancouver Island in mid-June. Of 30 tags deployed on juveniles, two instruments are still transmitting as of this writing. Both of these tags are on females that were just west of the Queen Charlotte Islands (~52°N, 132°W) in mid-June. A third tagged juvenile, a male, was in the north central Pacific (~42°N, 160°W) when last heard from in mid-June. Seventeen of 47 satellite tags deployed on fur seal pups were also still transmitting as of mid-June. At that time, the majority of the tagged pups were scattered across the North Pacific from long. 150° to 180°W, between lat. 40° and 50°N. However, three other pups were farther a field: one was still in the Bering Sea after spending the winter there, another was in the Gulf of Alaska, and the third was just southeast of the Kuril Islands in the northwestern Pacific.

By Jim Thomason

CETACEAN ASSESSMENT & ECOLOGY PROGRAM

Cook Inlet Beluga Survey, June 2007

After one of their airplanes disappeared near Anchorage, Alaska, in July 2006, Commander Northwest—the company that had provided aircraft for the NMFS Cook Inlet beluga surveys in Alaska since 1993—went out of business. When it became clear in May 2007 that the subsequent company, Northern Commanders, would not be able to provide a plane for the June 2007 beluga survey, we conducted exhaustive efforts to contract another private airplane. The impending listing of Cook Inlet beluga whales as endangered under the Endangered Species Act (ESA) triggered strong requests for the survey from NOAA Administrator Vice Admiral Conrad Lautenbacher, NMFS Assistant Administrator Bill Hogarth, AFSC Science and Research Director Doug DeMaster, and Senator Ted Stevens. However, with only a few weeks until the proposed survey, all reasonable options for contracting private aircraft withered due to sched-

uling conflicts. Then, on 5 June, NOAA's Aircraft Operation Center called to say they had managed to reschedule other projects in order to fly the beluga survey if we could arrive in Anchorage the next day. We did.

Accordingly, we conducted an aerial survey of the beluga population in Cook Inlet, 7-15 June 2007. The survey (47.2 flight hours) was flown in NOAA's Twin Otter at an altitude of 244 m (800 ft) and speed of 185 km/hr (100 knots), consistent with NMFS' surveys conducted each year since 1993. The study in June 2007 included one or more surveys of coastal areas (flown 1.4 km offshore) around most of the inlet and 1,342 km of transects across the inlet, effectively searching 25% of Cook Inlet and 71% of the coastline. Paired, independent observers searched on the coastal (left) side of the plane, where virtually all beluga sightings occur, while a single observer and computer operator/data recorder were on the right side of the plane. After finding belugas, multiple aerial passes were made with paired observers doing four or more independent counts of each group.

Daily median counts made on seven different days ranged from 64 to 126 belugas in the Susitna delta (between the Beluga and Little Susitna rivers), 0 to 9 belugas in Knik Arm, and 8 to 60 belugas in Turnagain Arm and Chickaloon Bay (including whales seen north of Point Possession) (Fig. 1). Belugas were not observed in lower Cook Inlet, which has been typical of the annual surveys. In June 2007, the highest daily median estimate, used here as an index for relative abundance (not corrected for effort nor for estimates of missed whales), was 224 belugas. This is below index counts for survey years prior to 1998 (305 belugas in 1993, 281 in 1994, 324 in 1995, 307 in 1996, and 264 in 1997) but higher than index counts made during the past 9 years (193 in 1998, 217 in 1999, 184 in 2000, 211 in 2001, 192 in 2002, 174 in 2003, 187 in 2004, 192 in 2005, and 153 in 2006).

By Dave Rugh, Kim Goetz, and Julie Mocklin

POLAR ECOSYSTEMS PROGRAM

Abundance and Distribution Surveys for Ice Seals Aboard the USCG *Healy* and the *Oscar Dyson*, 10 April – 18 June 2007

Researchers from the National Marine Mammal Laboratory's Polar Ecosystems Program (PEP) were joined by four Alaska Native seal hunters to conduct shipboard and aerial abundance and distribution surveys for the four species of ice-breeding seals (i.e., bearded, spotted, ribbon, and ringed seals) which are known to occupy the eastern region of the Bering Sea in spring and summer. The fieldwork was conducted during two cruises (10 April–12 May and 16 May–18 June 2007) on the U.S. Coast Guard icebreaker *Healy* and a cruise (3–30 May 2007) on the NOAA ship *Oscar Dyson* (Fig. 2).

Table 1. Number of seals and walrus observed during the *Healy* shipboard and helicopter surveys.

Species	Shipboard	Helicopter
Bearded seal	225	320
Ribbon seal	204	217
Ringed seal	46	24
Spotted seal	436	778
Unknown pinniped	205	228
Walrus	329	283
TOTAL	1,445	1,850

Whenever the *Healy* was moving and within 750 m of sea ice, between the hours of 0600 and 1800 local apparent time, at least two observers were posted on the bridge to record the presence of seals and walrus. Information on the species, group size, and distance from the ship's trackline (as calculated using angle measurements from inclinometers) was recorded along with sea-ice type and concentration, weather, and visibility. Where possible, the age, sex, and molt stage of animals were also recorded. In all, 1,116 individual seals (Table 1) were observed during 131 hours and 50 minutes of survey effort covering 1,116.0 nautical miles (nmi) of survey line.

Whenever the *Healy* was near ice and the weather conditions were conducive to flying, between 0900 and 1500 local apparent time, we also conducted line-transect surveys from a helicopter based aboard the icebreaker. Each flight had 2-3 observers and was flown at an altitude of 400 ft and a speed of 95 knots. A camera mounted on the airframe took digital pictures of the area underneath the helicopter every 2 seconds. These images will be analyzed for the presence of seals and to identify the type and percent cover of sea ice. As with the shipboard

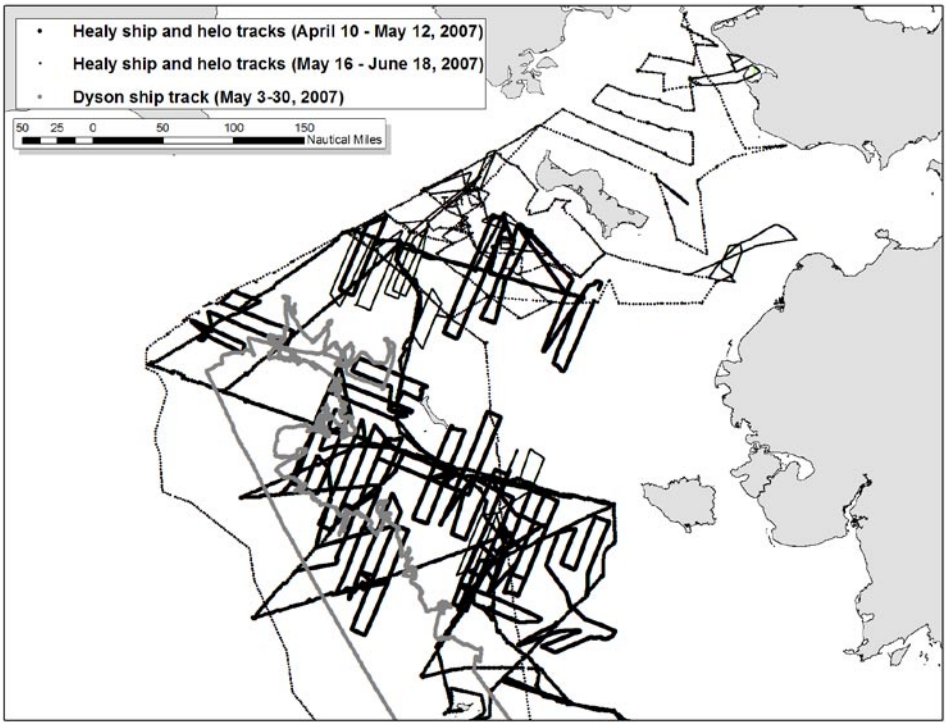

Figure 2. Map showing the ship and helicopter tracks of the *Healy* and *Oscar Dyson*. The first *Healy* cruise (10 April – 12 May 2007) is represented by a black line, the second *Healy* cruise (16 May – 18 June 2007) is represented by small black dots. The *Oscar Dyson* track is represented by a gray line.

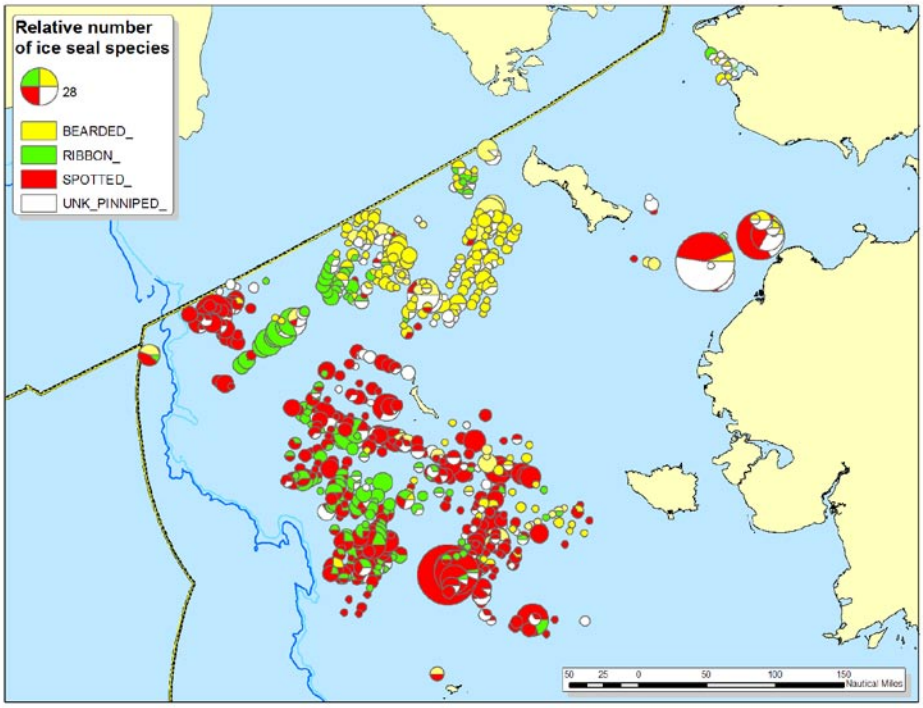

Figure 3. Map showing the abundance and distribution of seals observed during the *Healy* cruises. Counts of animals were summed over 5 nmi of survey trackline and are represented by a pie chart. The diameter of the pie chart represents the total number of animals in the 5 nmi of trackline, and the relative proportions of species seen are shown with different toned pie "wedges." Ringed seal sightings are not included in this map because so few were seen during the surveys.

surveys, information on the species, group size, and distance from the helicopter's trackline was recorded. In all, 1,567 seals (Table 1) were observed during 48 hours and 55 minutes of survey effort covering 4,414.4 nmi of survey line on 44 flights.

We also conducted line-transect surveys opportunistically from the *Oscar Dyson's* bridge. We recorded 296 seals or groups of seals while on effort, of which 47% were spotted seals, 22% were ribbon seals, less than 1% were bearded seals, and the remainder (30%) could not be identified to species, usually because of distance from the observer.

Preliminary analyses indicate some habitat partitioning among the three most abundant species of ice seals in spring (Fig. 3). This partitioning may be related to their foraging strategies. Bearded seals are benthic feeders and were most abundant in the shallow waters near the St. Lawrence Island polynia, where walrus (also benthic feeders) were also most abundant. Ribbon seals are known to forage at depths over 500 m and were most abundant at the southern edge of the sea ice and close to the shelf break, in close proximity to deep water. Spotted seals feed throughout the water column while over the Bering Sea shelf and tended to occupy the more interior areas of the pack ice. These associations tended to break down later in the season as the reduction of the ice field limited areas available for hauling out. Survey data from cruises planned for 2008 and 2009 will contribute further to a database that will eventually be used to calculate the springtime abundance and distribution of ice seals in the eastern Bering Sea.

By Michael Cameron and Peter Boveng

Telemetry of Ice Seals Captured During the USCG *Healy* and *Oscar Dyson* Research Cruises in the Eastern Bering Sea

The National Marine Mammal Laboratory's Polar Ecosystems Program (PEP) participated in three separate ice seal research cruises in the eastern Bering Sea this spring. Two cruises were aboard the U.S. Coast Guard icebreaker *Healy* (10 April – 12 May and 16 May – 18 June 2007) and one was aboard the NOAA ship *Oscar Dyson* (3–30 May 2007). One of the main objectives for the cruises was to deploy a large number of satellite-linked tags on ribbon and spotted seals. Ribbon seals and spotted seals are closely associated with sea ice during this time of year. The satellite-linked tags will provide critical information on haul-out behavior and seasonal changes in habitat use. Very little information is known about the movement of these seals, and the haul-out information will provide a key component for abundance estimates based on the extensive survey work done on the *Healy*.

We captured 48 seals in all, comprised of 32 ribbon and 16 spotted seals. We attached satellite transmitters to 28 ribbon and 12 spotted seals. Most of the transmitters were SPOT tags (Wildlife Computers, Redmond, WA) that were attached to the seals' hind-flippers. These tags will provide long-term movement data and haul-out timelines, but only when the seals are hauled out with their flippers exposed. The remaining transmitters were SPLASH tags (Wildlife Computers) that provide more detailed information about locations at sea and diving behavior; these tags must be glued to the hair on the seals' back or head and, thus, could only be attached to seals that had sufficiently completed their annual molt.

The majority of the captures occurred during the *Oscar Dyson* cruise. The *Oscar Dyson* departed Kodiak, Alaska, on the afternoon of 3 May and arrived at the ice edge and began research operations on the morning of 6 May. Our typical day consisted of survey watches from 1000 to 2200 Alaska Daylight Time (about 0600 to 1800 local apparent time), interrupted by small-boat excursions to capture and tag seals when we encountered sufficient concentrations of seals and suitable ice. Seals were captured on ice floes with hand-held landing nets. Our field crew consisted of four PEP biologists and two Alaska Natives from Kotzebue, Alaska. We conducted surveys or tagging operations daily until the evening of 28 May. The *Oscar Dyson* returned to Dutch Harbor, Alaska, on 30 May.

The sampling for each seal typically included length and girth measurements, mass, blood, a small piece of skin for genetic analysis, and any fecal material that was present on the ice for diet analysis. We obtained 13 blood, 45 skin, and 18 fecal samples from seals that we captured. In addition, we were able to collect 10 fecal samples and 14 samples of skin shed during the molt from seals that escaped our capture attempts. The dark flakes of skin are

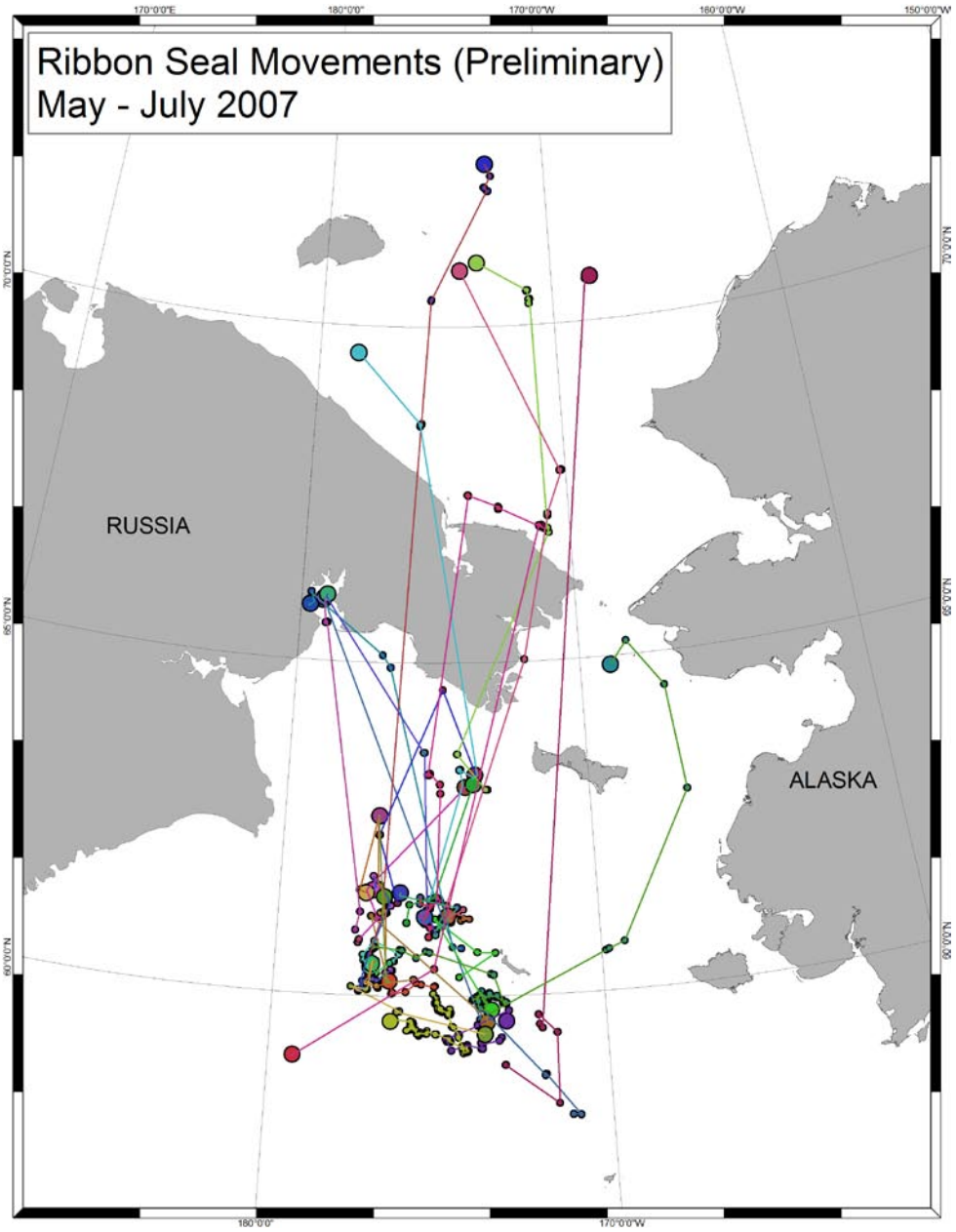

Figure 4. Map of ribbon seal movements from ARGOS satellite tags from May to July 2007. Larger dots represent the last known locations.

easy to find in the vicinity of molting seals' resting sites, and they contain sufficient DNA to support genetic analyses for investigation of stock structure.

Data from the deployed tags are already providing preliminary information on movement and show some intriguing patterns (Figs. 4 and 5). Ribbon seals and spotted seals have a strong association with the sea ice while molting. As the sea ice retreated, ribbon seals followed the ice north through the Bering Strait or into the Gulf of Anadyr. The spotted seals tended to head towards more coastal habitats along Alaska or Russia. These preliminary results are only the beginning of what we hope grows into a long-term dataset on ice seal behavior and ecology.

By Peter Boveng, Josh London, and Michael Cameron

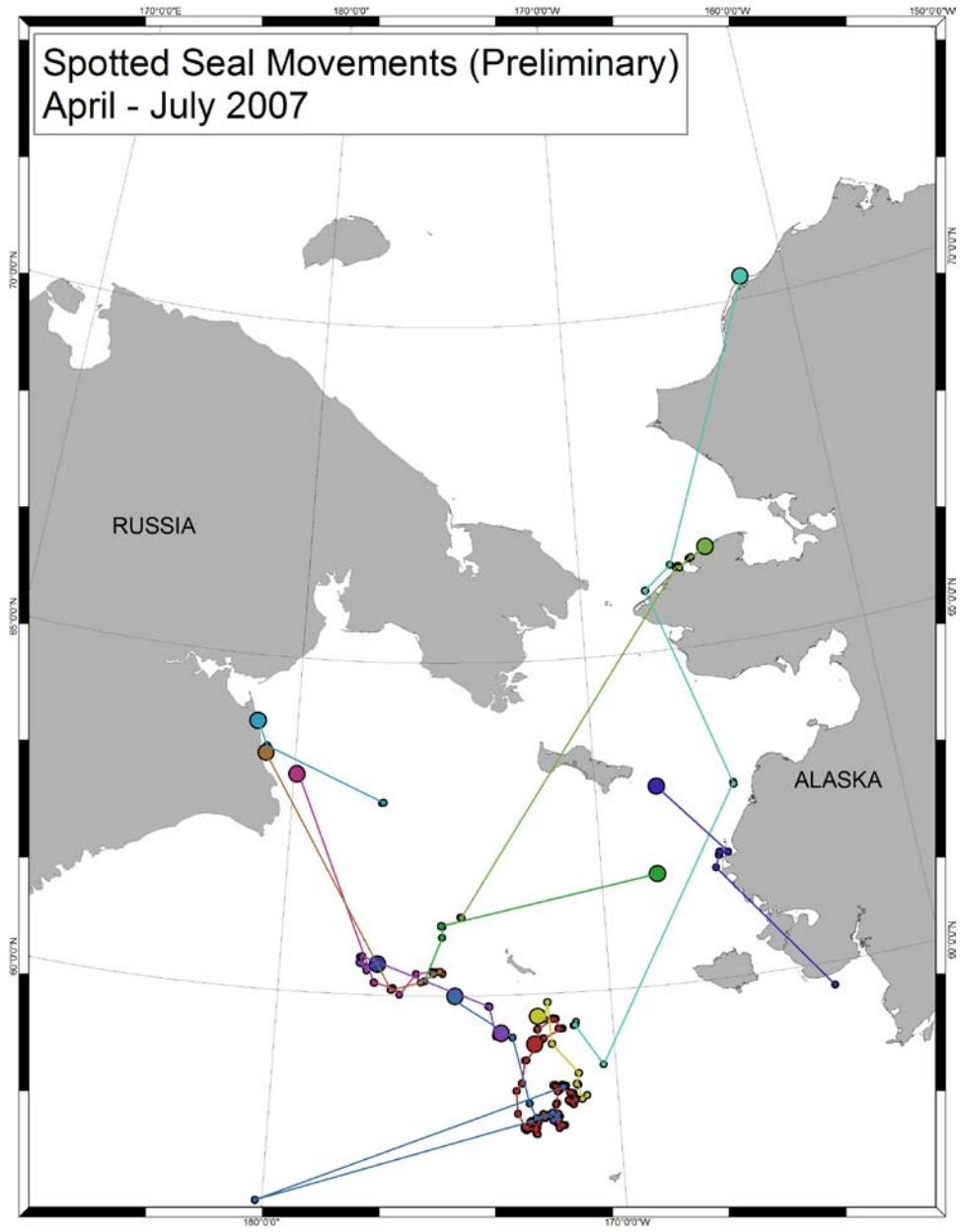

Figure 5. Map of spotted seal movements from ARGOS satellite tags from May to July 2007. Larger dots represent the last known locations.

RESOURCE ASSESSMENT & CONSERVATION ENGINEERING (RACE) DIVISION

GROUNDFISH ASSESSMENT PROGRAM

Annual Bottom Trawl Survey of the Eastern Bering Sea Continental Shelf

The eastern Bering Sea (EBS) Crab and Groundfish Trawl Survey conducted by the National Marine Fisheries Service (NMFS) commenced on 3 June 2007, continuing an annual series of assessment surveys, which began in 1971. The chartered fishing vessels F/V *Arcturus* and F/V *Aldebaran* will be used to sample 376 stations (Fig. 1) covering about 0.5 million km^2 of the Bering Sea shelf between the depths of 20 m and 200 m and from Bristol Bay to St. Lawrence Island. Data from the survey provides the North Pacific Fishery Management Council with up-to-date information on distribution, abundance, and population biology of key groundfish, crab, and other invertebrate species within the EBS continental shelf ecosystem.

After 3 days of preparations, the vessels departed Dutch Harbor and headed for Bristol Bay to conduct a gear test to compare red king crab

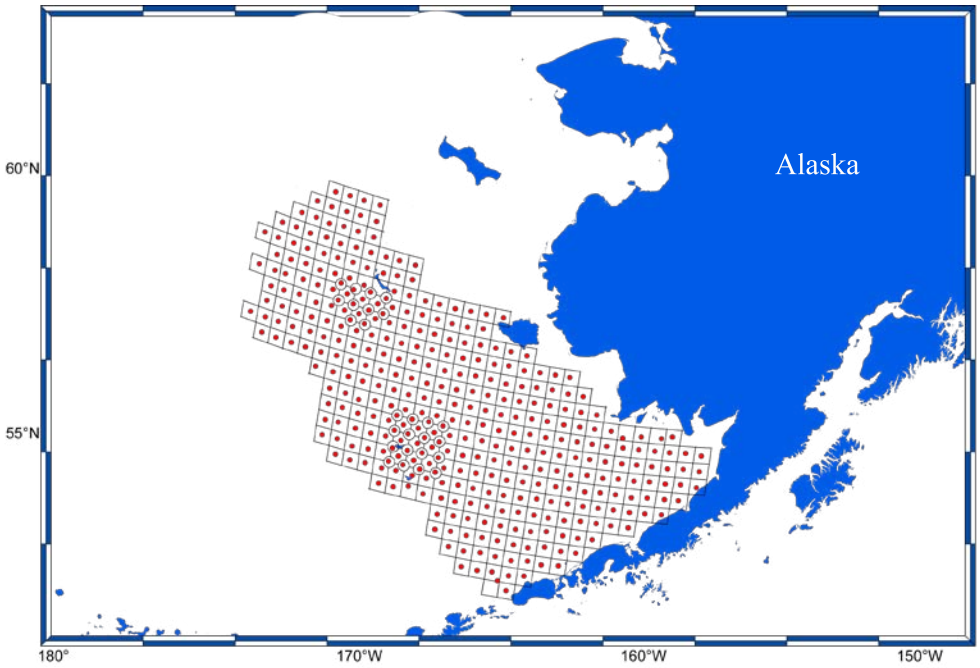

Figure 1. Established sampling grid used for the EBS crab and groundfish bottom trawl survey.

catches between the standard 83-112 Eastern trawl, used for the AFSC's EBS assessment survey, and the Nephrops trawl, used in crab surveys in the Canadian Gulf of St. Lawrence for the Bering Sea Research Foundation's (BSRF) pilot crab assessment survey. The purpose was to compare estimates of Bristol Bay red king crab abundance and biomass between two surveys taking into account dissimilar gear, sampling design, and methodologies. The BSRF's charter vessel F/V *American Eagle* alternately made 20 side-by-side paired tows with the *Arcturus* or *Aldebaran* on 8-9 June using a nonrandom complete block experimental design. Red king crab were weighed, sexed, enumerated, and measured (Fig. 2).

Other special studies in addition to the BSRF gear comparison are being done routinely during survey operations, and they include: 1) using high-quality acoustic data from survey charter vessels for improving the walleye pollock assessment during years without Midwater Assessment and Conservation Engineering (MACE) Division acoustic surveys; 2) assessing the effect of light intensity and penetration on the behavior and distribution of pollock; 3) reducing the variance of trawl biomass estimates of pollock using acoustic data from survey charter vessels; 4) assessing summer zooplankton biomass; 5) determining weight-length relationships for commercial crab species; 6) studying reproductive potential of Bristol Bay red king crab and *Chionoecetes* crabs; 7) collecting specimens for developing a key to decapod crustaceans; 8) continuing seabird and fishery interactions studies; 9) continuing trophic interactions and feeding ecology studies; 10) collecting vertebrae for studying age and growth of Alaska skate; 11) life history of Bering Sea octopi; 12) validating Pacific cod visual maturities; 13) studying sand lance (*Ammodytes)* taxonomy; 14) studying coral taxonomy; 15) collecting specimens for stable isotope analysis to study trophic ecology; 16) continuing study of bitter crab syndrome of *Chionoecetes*; 17) collecting DNA for prey item identification library; 18) studying biology and pathogenesis of *Ichthyophonus* in walleye pollock; 19) researching maturity and fecundity of the yellow Irish lord; 20) collecting live skate egg cases for rearing experiments, and 21) improving trawl gear monitoring.

Similar to 2006, bottom water temperatures were colder than average, and the cold pool (< 2°C) extended well into Bristol Bay. Lower than average water temperatures are implicated in an observed delay in the molting and spawning of female red king crab in Bristol Bay again this year, necessitating the resampling of 32 red king crab stations by the *Aldebaran* in Bristol Bay near the end of the survey, as was done previously in 1999, 2000, and 2006.

By Bob Lauth

Figure 2. RACE Division scientist David Somerton displays some of the red king crab specimens encountered aboard the charter vessel *American Eagle*.

Gulf of Alaska Biennial Bottom Trawl Survey

Three vessels chartered by RACE Division's Groundfish Assessment Program have begun more than 2 months of scientific bottom trawl surveys in the Gulf of Alaska, continuing data-gathering that has gone on every 2-3 years since 1984. These data are used to derive fishery-independent estimates of abundance, distribution, and biological condition for groundfish resources in the Gulf of Alaska.

Scientists on the chartered fishing vessels *Sea Storm*, *Gladiator*, (Fig. 3) and *Vesteraalen* are expected to complete about 825 survey trawl hauls over a 75-day period along the continental shelf and upper continental slope of the Gulf of Alaska. They started 25 May in Dutch Harbor and are scheduled to end their charters on 7 August in Ketchikan. The three boats started the survey near the Islands of Four Mountains, about 180 miles southwest of Dutch Harbor, and will work their way eastward to the U.S.-Canada border at Dixon Entrance. Cruise breaks for all three vessels will occur in Sand Point, Kodiak, and Seward. As of the end of June, when crews completed the second of four survey legs, about half of the stations had been sampled and the project is on schedule to be completed successfully. Each of the three boats holds six researchers plus the skipper and crew. In addition to core staff from the Alaska Fisheries Science Center, scientists from the California Academy of Sciences, the International Pacific Halibut Commission, the University of Washington, the Alaska Sea Life Center (Seward), and the University of Alaska Fairbanks are participating on various legs of the survey.

This biennial survey monitors trends in the distribution and abundance of important groundfish species such as walleye pollock, Pacific cod, flatfish, and rockfish. It also helps us measure various biological and environmental parameters such as sea surface and bottom temperatures and the size, age, and food habits of important groundfish. The survey has been carried out every other year since 1999. Before then, it was conducted every 3 years starting in 1984.

Each vessel makes 15-minute trawl hauls at specific, randomly preselected stations. The trawl catches are sorted, weighed, and enumerated by species. Samples will be collected from selected species to determine fish size and age, sexual maturity, and food habits. Data on the location and depth of the survey tows, the fishing performance of the trawl, and the temperature of the ocean are recorded using a variety of monitoring instruments on the vessel or attached to the trawl headrope. Sample depths will range from depths greater than 15 m near shore to 1,000 m on the continental slope.

Following completion of the survey in early August, scientists will edit and finalize the data they collected on fishing effort, catch rates, and fish size distribution and generate fishery-independent estimates of geographic and depth distribution, abundance, and population size composition by the end of September. Stock assessment modelers will then combine that information with data from the fishery and results of previous surveys to update the stock assessments used by the North Pacific Fishery

Figure 3. F/V *Sea Storm* and F/V *Gladiator*, two of the chartered commercial trawlers being used to conduct the 2007 Gulf of Alaska bottom trawl survey, lie at the dock in Sand Point, Alaska, at the end of the first leg of the survey.

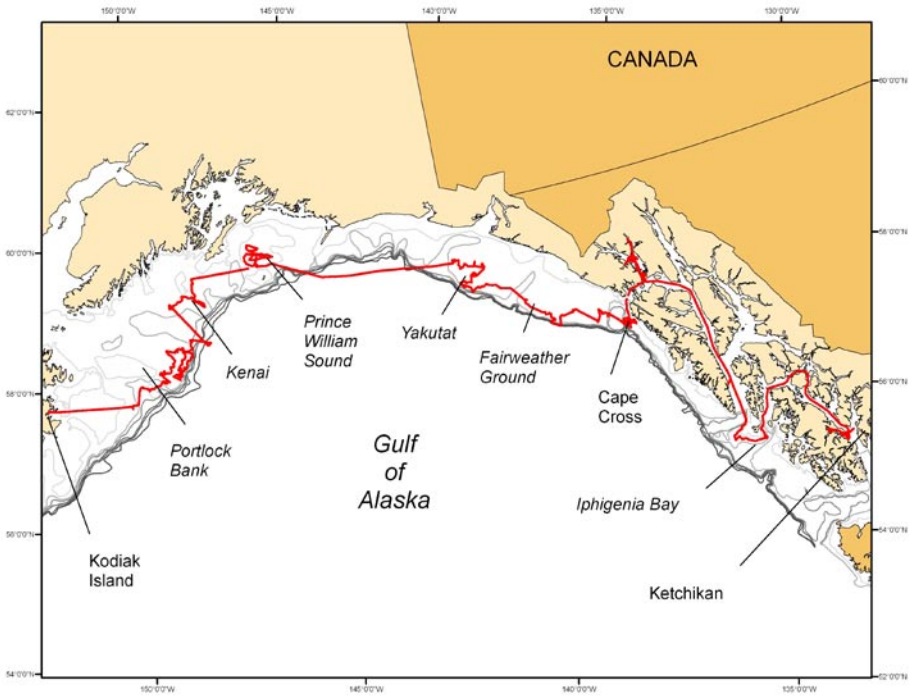

Figure 4. Recorded trackline of the NOAA vessel *Oscar Dyson* and areas of interest involved in the April 2007 untrawlable bottom investigation in the Gulf of Alaska.

Management Council to manage the groundfish stocks of the Gulf of Alaska.

By Mark Wilkins

Research on Untrawlable Portions of Bottom Trawl Survey Areas Conducted in Gulf of Alaska

Biennial bottom trawl surveys conducted in the Gulf of Alaska by NMFS are the primary fishery-independent data source used for estimation of commercial groundfish abundance. A persistent difficulty in the accurate estimation of groundfish biomass using trawl surveys is the unknown (but presumed large) amount of the continental shelf that is not fishable with standard survey gear. These surveys follow a stratified-random sampling design but involve substantial areas that cannot be sampled with standard survey trawls due to characteristics of the seafloor.

Many of these areas have been identified while searching for trawlable bottom during the standard trawl surveys, but these efforts suffer from two problems. First, because survey stations are defined by a 25 km^2 grid superimposed on the survey strata, the data collected to date do not allow sufficient granularity to examine trawlability on a fine scale. Second is the subjective nature of the designation process for untrawlable bottom. Different observers, with varying levels of experience in overall bottom trawling and use of the survey net and using different acoustic systems, make subjective decisions about the reasonable probability of completing a successful observation at a particular station. Inevitably, this leads to intervessel and interannual differences in the results of this process. To address these problems, a more objective and fine-scale method of evaluating the trawlability of the bottom with respect to the standard survey net is desirable.

The main impetus for the April 2007 cruise was to evaluate the utility of acoustic and ancillary data in the development of a more objective method of determining bottom trawlability. The scientific objectives of the cruise included estimating the critical angle differentiating trawlable and untrawlable bottom; evaluating the ability of split-beam echosounders to detect slopes in both alongship and athwartship directions and to detect substrate hardness/roughness; investigating the effect of water depth on perception of slope; examining how the interplay between hardness and roughness affects trawlability; evaluating the importance of heave,

pitch, and roll data on acoustic data quality in the estimation of trawlability; and evaluating how the use of multiple frequencies improves the estimation of trawlability

All operations were conducted 11-23 April aboard the NOAA ship *Oscar Dyson*. Multiple-frequency acoustic data were collected continuously along a series of transects with a Simrad ER60 echo sounder system incorporating five centerboard-mounted transducers at 18 kHz, 38 kHz, 70 kHz, 120 kHz, and 200 kHz. A drop camera system with strobe lighting was used for video validation of acoustic backscatter data.

Nearly the entire cruise time was spent conducting over 3,000 km of acoustic transects over areas of interest (Fig. 4). All of the planned transects in Kasaan and Glacier Bay were completed. The remaining time was spent conducting acoustic transects over historical tow and search paths in offshore waters, while slowly transiting towards Kodiak. All together, more than 50 GB of acoustic data were collected for analysis. It is expected that these data will provide a rich source of information to meet the scientific objectives of the project. Data analysis will take place in the upcoming months. Vessel motion data were successfully collected throughout the cruise as well. A total of 13 conductivity-temperature-depth (CTD) casts were made. The camera work was very successful on the first deployment, capturing outstanding video images of the seafloor, but the camera system subsequently failed and could not be repaired in the field.

By Michael Martin

Habitat Scientists Present at Two Conferences

MARINE HABITAT MAPPING TECHNOLOGY WORKSHOP FOR ALASKA

Members of the RACE Habitat Research group presented a series of posters at the Marine Habitat Mapping Technology Workshop for Alaska, held 2–4 April 2007 in Anchorage, Alaska. The primary goals of the workshop were to conduct a technical and methodological review of benthic habitat mapping in the marine waters of Alaska and to discuss approaches for selecting appropriate and cost-effective tools for this purpose. The posters provided an overview of the systematic approach that the Habitat Research group is using to develop quantitative habitat models for eastern Bering Sea (EBS) groundfish, with specific examples from current research projects.

The first poster "Mapping environmental variables to produce Essential Fish Habitat models" (by Bob McConnaughey, Cynthia Yeung, Steve Syrjala, and Keith Smith) summarized the iterative development of groundfish habitat models, our use of trawl survey estimates of abundance as an indicator of habitat quality, and emphasized the need for new environmental-data sources to adequately characterize habitat requirements in the region. The poster is available on the AFSC Web site at ftp://ftp.afsc.noaa.gov/posters/pMcConnaughey01_mapping.pdf.

The second poster "Using acoustics to characterize sediments for Essential Fish Habitat models" (by Bob McConnaughey, Lloyd Huff with the University of New Hampshire Center for Coastal and Ocean Mapping, Cynthia Yeung, and Steve Syrjala) described the Habitat group's research to identify more efficient methods for mapping the seabed sediments that affect EBS groundfish distributions. Pilot studies with a split-beam echosounder (38 kHz) and a sidescan sonar (455 kHz) indicate that acoustic systems are useful for this purpose, and a definitive study to develop operational guidelines for broad-scale acoustic mapping has been initiated. The poster is available o the AFSC Web site at ftp://ftp.afsc.noaa.gov/posters/pMcConnaughey02_acoustics.pdf.

The third poster "Adding ecological context to EFH models using groundtruthing technologies" (by Mark Amend, Jay Lomnicky, Keith Smith, Bob McConnaughey and Cynthia Yeung of the Groundfish Assessment Program, and Glenn McGillicuddy and Yuri Rzhanov with the University of New Hampshire Center for Coastal and Ocean Mapping) highlighted the need for groundtruthing of acoustic data, in order to improve understanding of ecological relationships and guide the formulation of our fish habitat models. This work described three complementary technologies and illustrated the resulting multi-faceted view of the physical and biological components of habitat. The poster is available on the AFSC Web site at ftp://ftp.afsc.noaa.gov/posters/pAmend01_context.pdf

The Habitat Research group also contributed to a fourth poster authored by research partners at the University of New Hampshire Center for Coastal and Ocean Mapping entitled "Evaluating Impact of Bottom Trawls Using Enhanced Data

Processing of High-Resolution Side Scan Sonar Imagery" (by Tianhang Huo, Lloyd Huff, and Bob McConnaughey). This research evaluates use of a sidescan sonar for quantifying change in a soft-bottom area of the EBS after disturbance with a commercial bottom trawl.

U.S. HYDRO 2007 CONFERENCE

Research by the Groundfish Assessment Program's Habitat Research group was also presented at the U.S. Hydro 2007 Conference held 14-17 May in Norfolk, Virginia. This gathering continued the series of hydrographic conferences that alternate between the United States and Canada. Lt. Jay Lomnicky, Benthic Mapping Specialist with the Habitat Research group, gave an oral presentation and submitted a paper entitled "Hydrography through the eyes of a fish – can acoustic backscatter be used to classify benthic fish habitat?" (by Jay Lomnicky, Bob McConnaughey, Cynthia Yeung, Keith Smith and Mark Amend). This work describes the ongoing collaboration between NOAA hydrographers and RACE fisheries biologists to improve understanding of fish habitat in the EBS while, at the same time, providing Internal Hydrographic Organization quality soundings for updating nautical charts. The presentation included various recommendations for matrix-managed projects of this type, based on the Habitat group's FISHPAC project experiences in summer 2006. More information on FISHPAC is on the AFSC Web site at http://www.afsc.noaa.gov/RACE/groundfish/hrt/fishpac.php

The Habitat Research group also contributed to a poster presented by research partners at the University of New Hampshire Center for Coastal and Ocean Mapping entitled "Brooke Ocean Technology's Free-Fall Cone Penetrometer: deployment experience aboard the NOAA ship *Fairweather*" (by Glenn McGillicuddy and Lloyd Huff with the University of New Hampshire Center for Coastal and Ocean Mapping, and Bob McConnaughey). Based on nearly 200 deployments during the group's FISHPAC experiment in 2006, the Free-Fall Cone Penetrometer (FFCPt) hardware and software were evaluated and various operational considerations were discussed. This experience indicated the FFCPt, with some refinement, could be a valuable tool that reduces the use of bottom grabs to distinguish sediment types in an area of interest.

By Bob McConnaughey

AFSC Deputy Director Jim Coe (left) presents Lt. Jay Lomnicky with the NOAA Corps Achievement Medal.

Lomnicky Receives NOAA Corps Medal

Lt. Jay Lomnicky, Benthic Mapping Specialist assigned to the Groundfish Program's Habitat Research group, has been awarded the NOAA Corps Achievement Medal. The award recognizes professional or leadership achievement based on sustained performance or specific achievement of a superlative nature. Lomnicky was recognized for his "sustained and extraordinary contributions to the success of integrated fisheries research and hydrographic surveying by NOAA in the eastern Bering Sea."

Lomnicky's shore billet is in direct support of NOAA's Matrix Management Initiative and involves coordinated efforts between NOAA Fisheries Service and the Office of Coast Survey. His "crossover" position is shared by the Office of Coast Survey (OCS), Pacific Hydrographic Branch (PHB) and the AFSC. While assigned to PHB, he has assisted in the support of ongoing hydrographic data acquisition and processing efforts. While working for the AFSC, Lomnicky participated in AFSC-directed fisheries research, most notably the FISHPAC project in the eastern Bering Sea. Technical accomplishments, including management of a new towed underwater video system (TACOS), contributed significantly to the success of the multi-mission FISHPAC cruise on NOAA ship *Fairweather*. His continuing leadership has fostered productive interactions between the hydrographic and fisheries components of NOAA, thereby advancing strategic goals for integrated ocean mapping.

By Bob McConnaughey

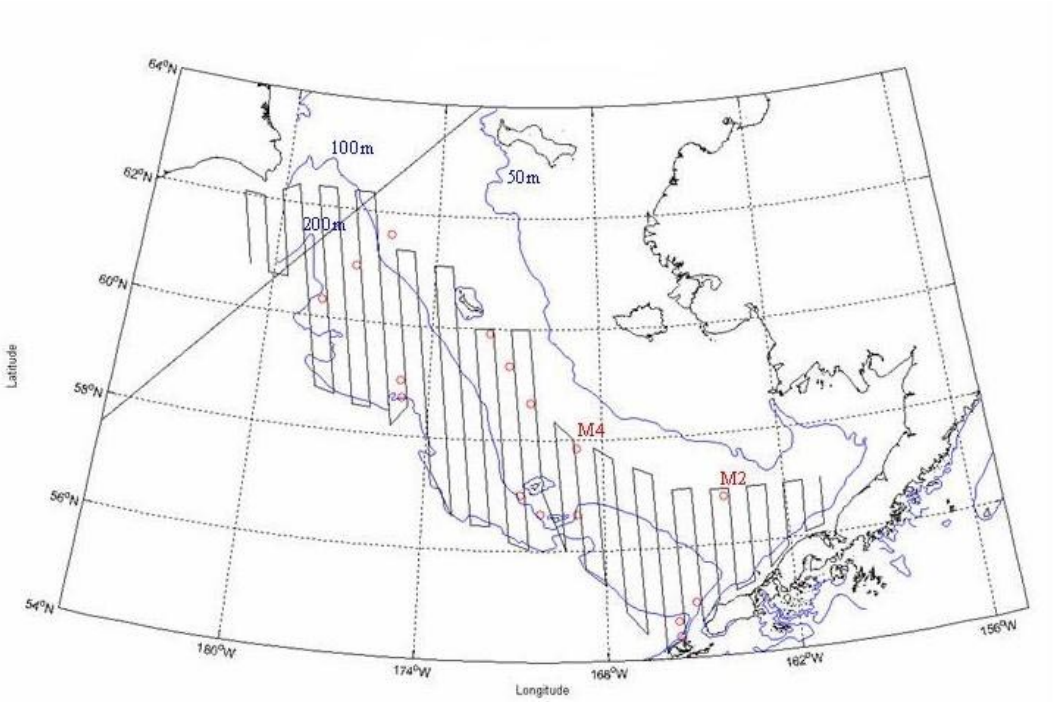

Figure 5. Acoustic survey trackline for the 2007 acoustic-trawl survey of the eastern Bering Sea shelf.

MIDWATER ASSESSMENT & CONSERVATION ENGINEERING (MACE) PROGRAM

Midwater Assessment and Conservation Engineering (MACE) Program scientists began an acoustic-trawl survey of the eastern Bering Sea aboard the NOAA ship *Oscar Dyson* on 1 June. This survey will continue through 30 July 2007, spanning the area along the outer Bering Sea continental shelf from outside of Bristol Bay to the U.S.-Russia Convention Line. Permission to survey in the Russian exclusive economic zone (EEZ) has been granted – allowing the survey area to be extended into the Navarin shelf region. The principal objective of the survey is to collect echo integration and trawl data to estimate the midwater abundance and distribution of walleye pollock (*Theragra chalcogramma*). The survey design consists of north-south oriented, parallel transects spaced 20 nmi apart (Fig. 5). In support of the survey objectives, acoustic and trawl data are collected during daylight hours. Nighttime operations – in addition to some limited daylight research time - include additional trawling, target strength data collection, gear tests of a multiple opening/closing codend device, net selectivity experiments, and CTD deployments.

By Neal Williamson

Acoustic Surveys in Ice-Covered Areas of the Eastern Bering Sea

Scientists from the MACE program conducted a study of the abundance and distribution of fish and plankton in the eastern Bering Sea in relation to seasonal sea ice cover. The goal of this work was to improve our understanding of the relationship between the abundance of fish and other animals and the position of the Bering Sea ice edge. Although there are major interannual changes in ice extent and ice persistence in the Bering Sea, little is known about the impacts of ice cover on the distribution of fish and plankton during winter months when much of the shelf is covered by ice. Previous work has shown that many species in the Bering Sea avoid the cold temperatures, and it is likely that areas of melting sea ice act as a barrier for fish due to the formation of very cold water at all depths. Because ice cover makes it difficult to sample fish with conventional sampling gear such as nets, acoustics was used measure the distribution of fish in ice-covered waters.

MACE scientists in collaboration with the vessel's crew surmounted several technical challenges and instrumented the U.S. Coast Guard (USCG) icebreaker *Healy* with scientific fishery echosounders. The equipment was used during an 10 April - 12 May cruise in the eastern Bering Sea as part of the

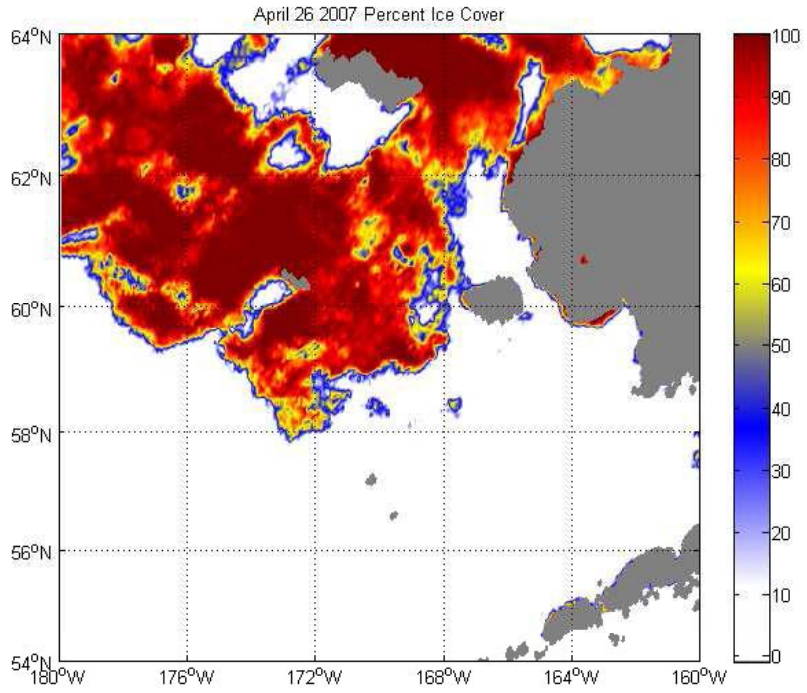

Figure 6. Sea ice cover present near the midpoint of the cruise (26 April). Percent of the sea surface covered by ice was estimated by the ASI algorithm on data from the AMSR-E satellite microwave sensor. Darker shading indicates increasing ice cover.

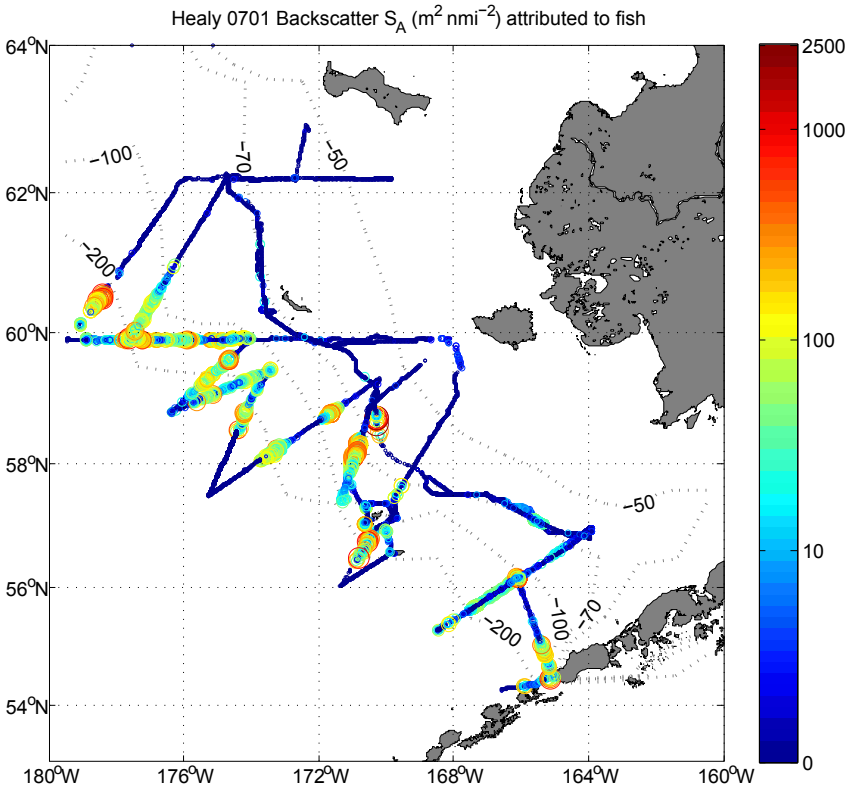

Figure 7. Acoustic backscatter at 38 kHz attributed to fish along the *Healy's* trackline. Depth contours in meters are indicated by the dotted lines. Symbol size and color are proportional to the abundance of fish.

Figure 8. Scientists and their sampling equipment are lowered from the deck of the USCG icebreaker *Healy* to the Bering Sea pack ice below.

interdisciplinary BEST (Bering Sea Ecosystem Study) program (see below). *Healy's* icebreaking capabilities allowed the ice-covered areas to be surveyed for the first time, while the NOAA ship *Miller Freeman* used the same instrumentation to survey in open water, and in the marginal ice zone at the same time. A multifrequency echosounding technique was used to distinguish acoustic backscatter from plankton and fish. Although analysis is ongoing, preliminary results indicate that the abundance of fish in the water column in the cold and shallow ice covered areas of the inner and middle shelf (depths <100 m) was much lower than in the ice free regions of the outer shelf at depths > 100 m (Figs. 6 and 7). Backscatter attributed to plankton (primarily euphausiids) was more evenly distributed, and euphausiids were at times abundant in the ice covered areas. More comprehensive analyses of the acoustic backscatter from both vessels in relation to water column characteristics, sea ice cover, and the summer distribution of pollock and euphausiids are currently under way.

By Alex De Robertis

RECRUITMENT PROCESSES PROGRAM

Scientists from the Recruitment Processes Program had a busy spring with involvement in four cruises in the eastern Bering Sea and Gulf of Alaska. The first cruise (10 April - 12 May), a collaboration with the National Science Foundation BEST (Bering Ecosystem Study; http://www.fish.washington.edu/research/best/) and NOAA's Pacific Marine Environmental Laboratory (PMEL), used the USCG Icebreaker *Healy* to sample larval fish and zooplankton behind the seasonal ice edge in the eastern Bering Sea (http://www.pmel.noaa.gov/foci/ice07/index.html; http://www.polartrec.com/best-cruise/overview). Other AFSC projects on the icebreaker included researchers from MACE using acoustics to document under ice fish distributions (see above) and researchers from the National Marine Mammal Laboratory (NMML) investigating the distribution and ecology of ice-dependent seals (see NMML report in this issue). The general goal of the research is to understand how sea ice affects the structure and function of the Bering Sea ecosystem so that we can predict how the loss of sea ice will affect this region (Fig. 8).

This was the Recruitment Processes Program's first opportunity to use a vessel capable of working well within the ice field, and taking advantage of this opportunity, we collected many plankton samples for later analyses in the laboratory. Scientists also periodically took samples of the ice for its physical, chemical, and biological properties. Recruitment Processes scientists also had the opportunity to talk to students from St. Paul and St. George Islands about the cruise and careers in science during a stop over and crew change at St. Paul Island.

The second cruise (7-18 May) was aboard the NOAA ship *Miller Freeman* in the Gulf of Alaska. Samples were collected for a project that aims to understand the mechanisms important for the transport of larval flatfish from the continental slope, inshore to nursery areas on the Bering Sea shelf. The North Pacific Research Board helps support this research, and the target fish is Greenland halibut (*Reinhardtius hippoglossoides*). Samples were collected primarily around the Pribilof Islands and Bering Canyon. Greenland halibut larvae were in some of the plankton tows and were shared with our collaborators from Oregon State University.

Recruitment Processes scientists also conducted our annual walleye pollock late larval cruise in Shelikof Strait, Gulf of Alaska. This cruise was also aboard the *Miller Freeman* and began in Dutch Harbor and sampled from Unimak Pass up to the middle of Shelikof Strait. The main objective of the cruise is to determine the number of larvae that have survived to the late larval stages and could potentially recruit to the fishery 2 years later. The abundances and size of the larvae are used to help predict potential recruitment of the year class.

Recruitment Processes scientists, as well as others from RACE Division Pathobiology and the AFSC Fisheries Interaction Team, oversaw the collection of ichthyoplankton and zooplankton on the 2007 eastern Bering Sea groundfish survey. These samples were collected to maintain the time series of plankton species and abundance from the Bering Sea ecosystem. These data are invaluable to understand if and how the ecosystem may be changing in response to climate.

By Jeff Napp

NEWPORT LABORATORY: FISHERIES BEHAVIORAL ECOLOGY PROGRAM

Causes and Consequences of Winter Mortality in Fishes

Examination of the ecology of fishes during winter has lagged well behind study of fishes in summertime. This discrepancy is due to the logistical impediments of winter field work as well as a lingering perception that winter represents a period of stasis in the life history. However, accumulating evidence demonstrates that the overwintering phase is a critical period in the recruitment dynamics of many marine, estuarine, and freshwater fishes, including some Alaskan species.

Fish populations impacted by winter mortality include a number of important North American and European resource species, yet the sources of this mortality remain unidentified in most populations where it has been documented. For example, the causes of the 1993 episode that reduced spawning biomass of Prince William Sound Pacific herring (*Clupea pallasi*) by approximately 80% are still unknown because of limited knowledge of environmental conditions during the event and evidence pointing to several alternative explanations. Among the potential sources, thermal stress and starvation have received the most research attention (Fig. 9). Other sources, including predation and pathogens,

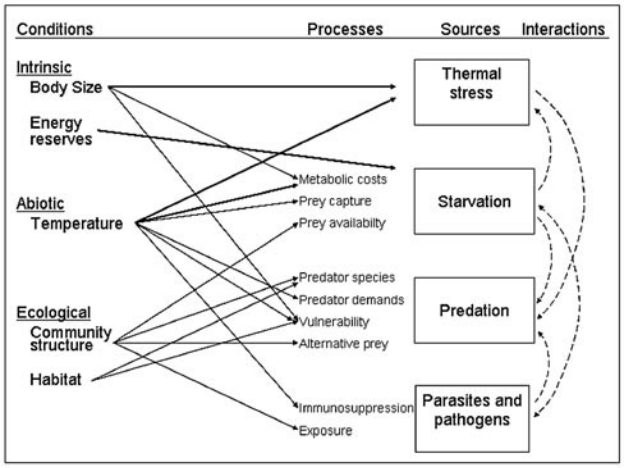

Figure 9. Schematic representation of factors influencing winter mortality in fishes. Primary Sources of winter mortality (in boxes) are influenced by environmental Conditions (intrinsic, abiotic and ecological) directly or indirectly (indicated by Processes). Heavy lines indicate relationships having received the most research attention to date. Likely Interactions between mortality sources are indicated by dashed lines.

have significant impacts but have received insufficient attention to date. Designs of more recent laboratory experiments have reflected recognition of the potential for interactions among these co-occurring stressors. One such experiment examined the interactive effects of winter temperature on salinity tolerance, swimming ability, and vulnerability to pathogens of Alaskan coho salmon (*Oncorhynchus kisutch*).

Geographic patterns in winter mortality are, in some cases, linked to latitudinal clines in winter severity and variability. However, for many freshwater species in particular, the effects of local community structure (predators and prey) may overwhelm latitudinal patterns. Many aspects of marine (and estuarine) systems differ from freshwater systems in ways important to overwintering fishes, the most important being the lack of isolating barriers in the ocean. While open population boundaries allow fish to adopt migration strategies minimizing exposure to thermal stresses, they may retard rates of evolution to local environments. Geographic patterns in the occurrence and causes of winter mortality are ultimately determined by the interaction of regional and local factors.

Winter mortality impacts population dynamics through episodic depressions in stock size and regulation of annual cohort strength. While the former tends to act in a density-independent manner, the latter can be density-dependent as most sources of mortality tend to select against the smallest members of the cohort/population. Determining the density-dependence of winter mortality will be a critical, but difficult, issue to resolve in specific populations. For example, recruitment of Bering Sea walleye pollock appears to be correlated with winter severity, implying a direct density-independent regulation. However, winter mortality is believed to result from increased inter-cohort cannibalism in cold winters due to increased spatial overlap between age groups, a mechanism likely to act, at least in part, in a density-dependent manner.

While some winterkills result in only temporary declines in abundance, others have had long-term impacts by altering the trophic structure and biotic controls on recruitment in the system. Most stock assessment and management regimes have yet to explicitly incorporate variability in winter mortality. However, potential management responses that are beginning to be applied include postponement of cohort evaluation (to after first winter of life), harvest restrictions following mortality events, and habitat enhancement.

Future research should place more emphasis on the ecological aspects of winter mortality including the influences of food web structure on starvation and predation potential. Beyond illuminating an understudied life history phase, studies of overwintering ecology are integral to advancing the primary initiatives in contemporary fisheries science including ecosystem management, habitat evaluation, and impacts of climate change.

By Thomas Hurst

KODIAK LABORATORY: SHELLFISH ASSESSMENT PROGRAM

New Kodiak Laboratory Director

Dr. Robert (Bob) Foy assumed his new position as Laboratory Director and Program Manager of the RACE Division's Shellfish Assessment Program at the Kodiak Fisheries Research Center in mid-May. Dr. Foy comes to the AFSC from his faculty position with the University of Alaska Fairbanks (UAF) School of Fisheries and Ocean Sciences and was stationed at the Fishery Industrial Technology Center in Kodiak. Bob has been involved in a broad range of research in Alaska associated with groundfish, forage fish, and groundfish fishery-Steller sea lion interactions. He has also served as an academic advisor or committee advisor/chair for graduate students at UAF. All are encouraged to welcome Bob into his new position at the Kodiak Lab and with the AFSC.

By Russ Nelson

Blue King Crab Ocean Acidification Research

Scientists from the Shellfish Assessment Program at the Kodiak Laboratory have been conducting research in collaboration with scientists at the Auke Bay Laboratories to assess the effects of ocean acidification on blue king crab. In the past decade the potential affects of ocean acidification on calcifying organisms have been the focus of a number of studies. The 2007 reauthorization of the Magnuson-Stevens Fishery Conservation and Management

Act recognized the importance of ocean acidification and recommended that the effects on the United States be studied. Ocean acidification is the decrease in ocean pH due to the carbonate system response to increasing CO_2 concentrations in the atmosphere and world's oceans. Atmospheric CO_2, rising since the beginning of the industrial revolution largely due to the burning of fossil fuels, has resulted in increased dissolution of CO_2 into the ocean. This has triggered a decrease of carbonate ion concentration, thus limiting the ability of calcifying (carbonate dependent) organisms, such as corals and pteropods, to form support structures.

In 2007 we expanded the experimental design to include a broader pH treatment to reflect preindustrial oceanic pH levels

The fishery resources managed by NMFS in the North Pacific are among the most vulnerable to the effects of ocean acidification. The North Pacific has conditions less favorable for calcification due to the increased solubility of calcium carbonate at lower temperatures and the inflow of CO_2-rich waters from deep ocean basins. As such, AFSC laboratories are ideally located to undertake research on ocean acidification and its impact on high latitude marine organisms. Cold water corals with calcite skeletons provide important habitat for commercially valuable fish and crustaceans. Fish that may not be directly affected by changing pH may suffer indirectly if their food source is impacted, as would be the case with pink salmon that consume calcifying zooplankters such as pteropods. Crustaceans, such as the commercially valuable king and snow crabs, use calcite to harden chitinous exoskeletons.

In 2006 the Kodiak and Auke Bay Laboratories collaborated to investigate the effect of reduced pH on the calcium uptake, growth, and survival of the early life stages of blue king crab (*Paralithodes platypus*). Blue king crab larvae (Figs. 10 and 11) were exposed to seawater of three different pH levels: the ambient level at Kodiak and two lower pH levels adjusted using hydrochloric acid. Results indicated that lower pH negatively affected survival to and growth and calcium content of the first juvenile stage of blue king crab. In 2007 we expanded the experimental design to include a broader pH treatment to reflect preindustrial oceanic pH levels and another low pH level. Additionally, we are assessing the progression of calcite and morphological development effects of acidification by sacrificing larvae at multiple developmental stages and taking calcite and morphological measurements. Experiments are conducted in a controlled temperature setting at the Kodiak Fisheries Research Center. The Kodiak Laboratory will soon be home to a CO_2 delivery system that will allow researchers to adjust the pH of treatment water with CO_2. This system will better reflect the effects of changes in the carbonate system due to increases in CO_2 on organisms than adjusting pH with hydrochloric acid. Kodiak Laboratory scientists are working with others in the AFSC to develop an AFSC ocean acidification research plan and will expand research to include additional crab species and life stages in future years.

By Sara Persselin

Figure 10. Zoeal stage 2 larval blue king crab were exposed to numerous pH level treatments.

Figure 11. Juvenile stage 1 blue king crab were exposed to numerous pH level treatments.

RESOURCE ECOLOGY & FISHERIES MANAGEMENT (REFM) DIVISION

RESOURCE ECOLOGY AND ECOSYSTEM MODELING PROGRAM

Fish Stomach Collection and Lab Analysis

Laboratory analysis was performed on 2,904 groundfish stomachs from the eastern Bering Sea and on 677 groundfish stomachs from the Gulf of Alaska. A total of 620 stomachs were collected during the initial legs of the Gulf of Alaska trawl survey and 533 stomachs were analyzed at sea. Fisheries observers collected 1,277 stomach samples from the Bering Sea. A total of 8,311 records were added to the groundfish food habits database.

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

Multispecies and Ecosystem Modeling

As part of essential fish habitat (EFH) research, scientists from the Resource Ecology & Ecosystem Modeling (REEM) Program developed a method for mapping predicted growth rates from stomach contents analysis overlayed with the energetic costs of foraging as determined from bioenergetics models for walleye pollock. These maps are being made for the range of observed conditions (e.g., "cold years" vs. "warm years") and will be available for other modeling efforts, such as for coupling with spatially explicit lower trophic level production models and fish migration models. An extensive literature review was performed to gather data on prey quality (caloric density) from available sources. A bioenergetics model was also implemented for pollock which makes direct use of diet composition and water temperature data in the groundfish food habits database. The initial results of this work are currently being examined and reviewed.

By Kerim Aydin and Beth Matta

Resource Ecology: Sculpin Age and Growth

The ages of 733 sculpins have been determined as part of a North Pacific Research Board (NPRB) project to examine the life history of sculpins. Ages were determined for 344 and 166 yellow Irish lords (*Hemilepidotus jordani*) in the Aleutian Islands and eastern Bering Sea, respectively, that were collected in 2006. Thin sectioning (Fig. 1) was determined

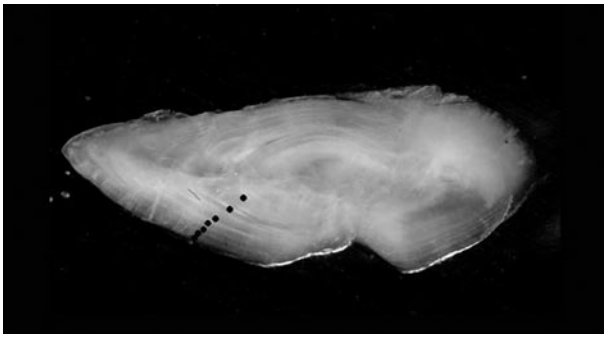

Figure 1. Thin section of a yellow Irish lord otolith (age: 7 years; 37 cm, female).

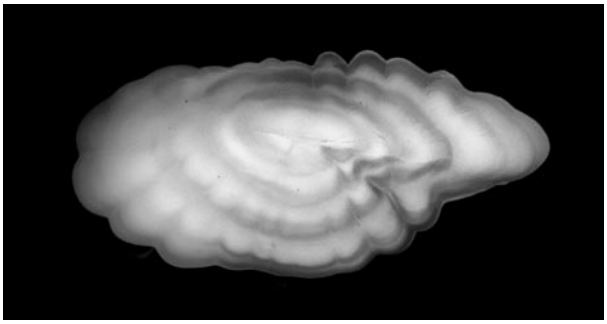

Figure 2. Warty sculpin otolith aged through surface reading (5 years old).

to be a more appropriate method for ageing yellow Irish lords than the break and burn method. The 2006 eastern Bering Sea shelf survey collection of warty sculpin (*Myoxocephalus verrucosus*) has also been aged (n = 186). A number of warty sculpin specimens were aged through surface reading (Fig. 2); otherwise the break and burn method was used. The break and burn method is also being used for the other sculpins in the study. A total of 37 bigmouth sculpin (*Hemitripterus bolini*) samples have been aged from the 2004 eastern Bering Sea slope survey and the 2006 Aleutian Islands survey. The 2005 eastern Bering Sea shelf survey collection of the great sculpin (*Myoxocephalus polyacanthocephalus*) was aged in early 2006 prior to NPRB funding for this project. Currently in the queue for ageing is the 2005 eastern Bering Sea survey collection of the yellow Irish lord (n = 222) and the warty sculpin (n = 176) and the 2006 eastern Bering Sea survey collections for the plain sculpin (*M. jaok*) (n = 445) and great sculpin (n = 398).

Quality control has been maintained throughout the ageing process. Although time intensive for new species, the development of ageing criteria and recognition of different patterns has been established for each species with the exception of the plain scul-

pin. A 100% test by the AFSC's Age and Growth Program has been used for each species due to the novelty of the species being aged. The standard 20% testing of samples is initiated only after it has been determined that the quality of the ages by the first reader is satisfactory. So far, 20% testing has been initiated with the yellow Irish lord and the great sculpin. Testing and the resolution of discrepancies have not been entirely completed, so the official release of the ages has not been made. Based on work so far, however, the maximum age for the yellow Irish lord in both the eastern Bering Sea and the Aleutian Islands appears to be in the mid-20s, while the warty sculpin and bigmouth sculpin appear to be in the mid- to high teens. The great sculpin, as exhibited from the 2005 eastern Bering Sea collection, has a maximum age of 16 years.

By Todd TenBrink

Sculpin Reproduction and Maturity

Approximately 500 ovary samples have been processed, spanning all five sculpin species mentioned above. Histological preparation has been initiated by a laboratory contractor. Analysis is under way on samples received to assess maturity stage. Based on a review of the histology of about 275 yellow Irish lord ovary samples collected during the months of June and July, several stages exist. It appears that the spawning period may begin in mid-July/early August for both the eastern Bering Sea and Aleutian Islands regions. The length of the spawning period is still under investigation, as more samples will need to be collected around this time period. Length and age-at-maturity (first, 50%, and 100%) estimates will be available for the yellow Irish lord after final processing of the 2006 and 2007 survey samples. A greater sample size is needed for other sculpin species to assess maturity. Observations from samples collected during the summer indicate that ovaries are in a resting or spent stage for the *Myoxocephalus* sculpins. These observations were validated through a review of histology. A few great sculpin ovaries (from specimens > 55 cm) collected in late January-early March 2007 by observers in the eastern Bering Sea were large and full of eggs, indicating a possible winter spawning period. Ovary stages of bigmouth sculpin are still being reviewed. Fecundity will be investigated later this year for selected species.

By Todd TenBrink

International Collaborations

On 21-23 May, Kerim Aydin (REEM Program) chaired a workshop of the North Pacific Marine Science Organization (PICES) Climate Forcing and Marine Ecosystems (CFAME) Task Team, with the purpose of developing a comparative, predictive, conceptual framework for connecting climate forcing to marine ecosystems, specifically with reference to long-term biological forecasts driven by Intergovernmental Panel on Climate Change (IPCC) climate modeling scenarios. Ecosystems that were studied were the California Current, Oyashio/Kuroshio Currents, and East China/Yellow Sea. The workshop was attended by 10 scientists from the United States, Japan, Canada, and the Republic of Korea. The attending scientists developed specific tables of key driving physical variables affecting range, recruitment, spawning grounds, feeding/growth, and adult survival of central fish species in each ecosystem, which will be used to extract specific climate variables from IPCC predictive models to predict the future state of these ecosystems.

By Kerim Aydin

SEABIRD INTERACTIONS

During 3-29 May, REEM scientist Shannon Fitzgerald participated in the National Marine Mammal Laboratory's (NMML) Ice Seal Cruise aboard the NOAA ship *Oscar Dyson* as a seabird observer (see NMML's Polar Ecosystems Program report). This work is part of a collaborative effort with the U.S. Fish and Wildlife Service (USFWS) Office of Migratory Birds Management in Anchorage,

Figure 3. Short-tailed albatross.

Alaska. Seabird observations were conducted while the ship was in transit from Kodiak to the pack ice north of the Pribilof Islands during morning and evening transects to and from the ice edge as the ship worked westward and northward along the pack-ice edge and during the transit back to Dutch Harbor from northwest of St. Matthew Island. Some sighting transects were also completed during ice seal sighting efforts conducted by NMML staff. The AFSC is coordinating closely with Dr. Kathy Kuletz and Dr. David Irons of the Migratory Birds Office to support seabird research on AFSC-led research cruises. This was the first time seabird sighting transects had been conducted on the NOAA ship *Oscar Dyson*. The cruise was led by NMML and focused on ice seals in the Bering Sea pack ice. This is an important environment for birds as well, and used extensively by northern fulmars, common and thick-billed murres, least and crested auklets, glaucous gulls, and other species. A highlight of the trip was the sighting of an adult and juvenile ivory gull.

The second quarter was also an important time to again conduct the point count or stationary seabird sighting surveys from other platforms, such as NMFS charter groundfish cruises. Materials were prepped for deployment and new staff trained to carry out the seabird surveys. Training was also provided to the Northwest Fisheries Science Center's West Coast groundfish team so that our collaborative work between the two Centers could continue.

Of special interest are short-tailed albatross sightings. Our seabird sighting protocols require that birds be noted only when they occur within a specific area. However, we are very interested in all sightings of the endangered short-tailed albatross. The groundfish team on the research charter vessel *Vesteraalen* was very excited to report daily observations of short-tailed albatross between the Islands of the Four Mountains and Unimak Pass (Fig. 3). These observations were also recorded and forwarded to Greg Balogh of the USFWS Ecological Services Branch, Alaska, and entered in a database.

By Shannon Fitzgerald

ECONOMICS & SOCIAL SCIENCES RESEARCH PROGRAM

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

Economic performance measurement is a key element in evaluating the impacts of fishery management decisions, yet relatively little attention has been paid to this area in the fishery economics literature. Existing studies tend to focus on fish harvesting and technical efficiency, capacity utilization, or quotas. Another important aspect of fishery performance, however, pertains to the revenue generated through fish processing, which is linked to the way fish are harvested, as well as the products produced from the fish.

In this study, Economics & Social Sciences Research (ESSR) Program researcher, Dr. Ron Felthoven, and Dr. Catherine Morrison Paul (University of California, Davis) econometrically estimate a revenue function, recognizing potential endogeneity and a variety of fishing inputs and conditions, to evaluate the factors underlying fishing revenues in the Alaskan pollock fishery. The authors find significant own-price supply responses and product substitutability, and enhanced revenues from the increases in season length and the number and duration of tows induced by the American Fisheries Act. They also find significant growth in economic productivity – higher revenues over time after controlling for observed productive factors and price changes, which exceeds that attributable to increased harvests.

By Ron Felthoven

Employing a Cost Engineering Approach to Estimate Vessel Expenditures

To conduct an economic analysis of a fishery, it is critical that one obtains or estimates the cost and expenditures incurred by the vessels operating within that fishery. Researchers often depend on vessel mail surveys for obtaining such information. However, the information requested in the surveys is considered sensitive and confidential to many vessel owners who are reluctant to provide it. An alternative approach to obtaining the same information is to survey the businesses that provide goods and services to fishermen. As part of an on-

going regional economic data collection project in the Southwest and Gulf Coast regions of Alaska, we are planning to survey/interview local businesses and boat builders and dealers. From local businesses we will get data on sales to harvesting vessels. From vessel builders and dealers we will get information on many of the operating and maintenance costs.

Specifically, for obtaining the cost information from boat builders and dealers we will use a cost engineering approach to estimate the maintenance, replacement, and hourly vessel operation costs. First, a "proxy" (an average) boat will be developed for each fish harvesting sector based on information on engine horsepower, electrical generation capacity, gross and net weight, gear types, and other technical information available from data sources such as the Commercial Fisheries Entry Commission. Once a proxy boat is developed we will ask boat builders and suppliers to provide us with information about depreciation, maintenance, replacement, and operation costs using industry guidelines. With this information we will be able to undertake much of the research we plan to conduct for these sectors of Alaska. By utilizing the cost engineering approach we hope to diminish the public burden associated with typical mail-out surveys to vessel owners.

By Chang Seung

Halibut Sport Fishing Survey Data Collection Completed

An economic survey developed by Dr. Dan Lew (EESR Program) and Professor Doug Larson (University of California, Davis) to collect the data necessary to understand recreational angler preferences for saltwater fishing in Alaska has been completed. The survey collected information about each angler's 2006 Alaska sport fishing activities (primarily saltwater) and preferences that will be used to estimate several economic models for assessing the impacts of potential regulatory changes on sport angler behavior.

The mail survey was initially distributed to a stratified sample of 4,000 Alaska resident and nonresident anglers who were licensed to sport fish during 2006. Several follow-up mailings were conducted, in addition to telephone contact, to maximize response rates for this voluntary survey. In the end, an overall response rate of approximately 57% was achieved.

Over the summer the data will be edited and summarized, and supplemental data will be collected to facilitate construction of key economic variables that are necessary inputs in the economic models. A summer research assistant, Jeff Ferris, will assist in these activities. Although some preliminary modeling will occur over the summer, the full data analysis cannot proceed until after these activities have been completed.

By Dan Lew

Using Bayesian Vector Autoregression (BVAR) to Identify Inter-industry Relationships for Alaska Fisheries

Using monthly borough-level employment data from 1990 to 2005, Dr. Chang Seung (ESSR Program) and Professor Sung Ahn (Washington State University) are developing a time-series model called a vector autoregression (VAR) for the fisheries off Alaska. The goal of this project is to identify the relationship between industries (with particular interest in seafood industries) for select fishery-dependent boroughs or regions so that researchers can better understand the socioeconomic impacts of fishery-related changes as well as shocks in other industries. The modeling approach developed here will avoid many of the problems that often arise in applying VARs such as insufficient degrees of freedom, multicollinearity, and poor out-of-sample forecast performance. This will be accomplished by utilizing nonsample Bayesian prior information contained in the input-output tables within the commercially available IMPLAN data set (which defines the linkages and multiplier effects among various sectors throughout the United States for a subset of our industries of interest). These priors will be incorporated as stochastic restrictions to the system. The Bayesian methods are expected to increase the precision of the estimates, which will help produce more useful models for future applied analyses.

By Chang Seung

STATUS OF STOCKS & MULTISPECIES ASSESSMENT PROGRAM

Aleutian Islands Cooperative Acoustic Survey Study

Status of Stocks and Multispecies Assessment (SSMA) Program scientists Steve Barbeaux and Libby Logerwell conducted the Aleutian Islands Cooperative Acoustic Survey Study from 17 March to 20 April 2007. The purpose of the study was to assess walleye pollock abundance in the central Aleutian Islands and to test the feasibility of managing an Aleutian Islands pollock fishery at a finer temporal and spatial resolution using near real-time acoustic surveying. To accomplish these objectives two acoustic surveys were conducted aboard a commercial fishing vessel equipped with a Simrad ES60 echosounder and a 38kHz split beam transducer. The vessel was also equipped for pelagic pollock fishing. The survey covered the area between Seguam Island and Amchitka Pass (long. 173°W to 179°W) on the north side of the Aleutian Islands archipelago.

To verify the acoustic data and to support the study, 1,300 metric tons (t) of walleye pollock were harvested within an area that included waters within 20 nmi of Steller sea lion haulouts and rookeries. This harvest was permitted under an experimental fishing permit (EFP) awarded to the Aleut Enterprise Corporation. The acoustic survey and fishing were conducted onboard the fishing vessel *Muir Milach*, skippered by Captain Dave Wilmore. Conducting the project within Steller sea lion critical habitat was necessary because pollock aggregations had to be encountered to support the work, and historical information about the occurrence of pollock indicated that pollock aggregations were likely to occur inside critical habitat.

The acoustic and biological information from the project will be used to determine: 1) if it is feasible to conduct acoustic surveys in the Aleutian Islands subarea using commercial fishing vessels, 2) if the data collected in such a manner is of sufficient quality for management purposes, and 3) if the local aggregations of pollock are stable enough during spawning season to allow for fine-scale spatial and temporal management. Additionally, genetic samples were collected that will be used for stock structure analysis.

By Libby Logerwell

Flatfish Stock Assessment Review

On 11-14 June 2007, the SSMA Program hosted a review of the Gulf of Alaska and Bering Sea/Aleutian Islands flatfish stock assessments. An independent review of these ecologically and commercially important stocks was desired to assess the quality of the assessments and to ensure that the North Pacific Fishery Management Council (NPFMC) bases its harvest decisions on the best available information and science. The review was conducted by three scientists from the Center for Independent Experts who were contracted through the University of Miami.

In addition to detailed discussions of the flatfish stock assessments, presentations were made by various AFSC staff on age and growth, early life history studies, gear research experiments on catchability, the Groundfish Observer Program, and the role of flatfish in the ecosystem. A report outlining the strengths and weaknesses of the flatfish stock assessments will be made available in July 2007. The SSMA Program looks forward to the reviewers' comments which will improve the stock assessment advice.

By Tom Wilderbuer

Integration of Environmental Information in Fisheries Management Advice

SSMA scientists Paul Spencer and Jim Ianelli were invited to present case studies at the International Council for the Exploration of the Sea (ICES) headquarters in Copenhagen, Denmark on 18–22 June 207. The meeting was titled "Workshop of the Integration of Environmental Information into Fisheries Management Strategies and Advice" with the following objectives: 1) estimate the consequences of environmental variability (including "regime shifts") for the biological reference points and other measures which are currently used to guide fisheries management; 2) carry out analyses and formulate short-, medium-, and long-term integrated advice for the selected cases and compare this with traditional methodology; 3) bearing in mind possible fisheries and ecosystems objectives, identify, develop, and evaluate procedures for improving fisheries management strategies and advice by including environmental information; and 4) identify future directions and needs, including operability, to bring forward the process of incorporating ecosystem advice. Four main categories for evaluations

were along productive capacities related to somatic growth, recruitment, survival, and spatial patterns. In addition to the eastern Bering Sea pollock and flatfish presentations given by REFM staff, the species/stocks covered for other case studies included: Greenland cod, North Sea cod, Northeast Atlantic sardine, North Sea herring, Northeast Arctic cod, Baltic Sea cod, Baltic Sea sprat, Bay of Biscay anchovy, California sardine, and South African anchovy. Summaries of the case studies presented are as follows.

Case study of eastern Bering Sea Pollock: impact of environmental variability on management advice

Advice to managers is adjusted to account for environmental conditions for eastern Bering Sea pollock. Formally, the adjustments occur through the added stochastic components of environmentally driven demographic shifts (e.g., mean weight at age) and through the shape of the assumed stock-recruitment relationship. The latter is justified based on analyses of stomach content data coupled with models to show that cannibalism has an impact on subsequent recruitment levels. The stochastic components (measurement errors together with environmentally driven process errors) affect quota recommendations by increasing the uncertainty of the F_{msy} estimates. Higher uncertainty in F_{msy} estimates result in lower values for quota recommendations due to analyses (shown in the original amendment to the Fishery Management Plan) that have determined that the harmonic mean value is appropriately risk-averse. Explicit qualitative adjustments to the pollock quota recommendations are done through the process communicating apparent ecosystem changes (e.g., increased predation by arrowtooth flounder for Gulf of Alaska pollock and the lack of acoustic back scatter seen in the Bering Sea during summer survey of 2006). The latter effectively lowered the ABC recommendation by 118,000 t.

Environmentally affected components of stock productivity that were reviewed included recruitment, growth, mortality and the spatial distribution of the stock. Recruitment affects quota recommendations by the functional form and the uncertainty of that form. Information on the impact of different climate regimes on pollock recruitment appears to be relatively weak, though during the late 1950s and 1960s, recruitment (based on relatively poor data) appears to have been well below the average from 1970 through 2000. The importance of prerecruit surveys was evaluated through simulations of likely data outcomes for 2007 and shows that without a survey, the likelihood for exploiting at higher rates was greater. The importance of direct observations on prerecruits as opposed to environmental proxies (e.g., correlative studies on factors related to recruitment success) was shown to be critical in providing timely recommendations on maximum quota levels. Stochastic components due to growth variability were shown to lower advice on quota recommendations by about 20,000 t, a relatively small percentage of the total. However, this evaluation did not account for possible trends in mean weight-at-age which may reduce the adjustment and provide a better basis for short-term projections. Retrospective analyses are useful to evaluate errors in model structure that should be included for testing purposes. For example, retrospective patterns may be caused by a combination of factors including recruitment processes, natural mortality, somatic growth, and distribution (stock availability to fishery and surveys). Linking information on multispecies modeling results may help to determine the extent that unaccounted natural mortality is contributing retrospective patterns compared to other possibilities such as movement.

Eastern Bering Sea yellowfin sole case study

The eastern Bering Sea has exhibited substantial variability in temperature in recent decades and has shown a marked warming trend in recent years. These changes in temperature appear to significantly affect trawl survey catchability of yellowfin sole (*Limanda aspera*) and flathead sole (*Hippoglossoides elassodon*) based on analyses from stock assessment models. These models use a "global catchability" in which estimated temperature-dependent survey catchability is a function of the annual temperature averaged over the entire survey area. However, spatial differences in temperature between survey tows may result in differential responses to the trawl gear. Gear studies indicate that eastern Bering Sea flatfish are herded into the net path from the trawl bridles, and if the flatfish swimming behavior is affected by temperature, then the degree of herding may also be affected. Thus, we evaluated a "local catchability" model in which the estimated survey catchability at a given trawl station was a function of the local temperature. For yellowfin sole, both

the global and local methods result in a statistically significant positive relationship between catchability and temperature. The increasing trend in EBS temperatures from 1999 to 2005 had a substantial effect on estimated yellowfin sole biomass when adjusting for temperature-dependent catchability. For example, the estimated 2005 total biomass declined 7% when global temperature-dependent catchability was used and the harvest recommendation dropped by nearly 10,000 t. To assess the importance of including factors affecting survey catchability, a management strategy evaluation (MSE) was developed. The MSE analysis showed that failing to account for temperature-dependent catchability resulted in underestimates of biomass during periods of low catchability and overestimates during periods of high catchability. Our results show that current assessment methods should include factors affecting survey catchability to reduce the variability in catch.

By Jim Ianelli and Paul Spencer

AFSC Hosts Pacific Cod Technical Workshop

At the request of the Scientific and Statistical Committee (SSC) of the NPFMC, the AFSC convened a public workshop to examine various technical issues pertaining to the assessments for Pacific cod in the Bering Sea (BS), Aleutian Islands, and Gulf of Alaska (GOA). The workshop took place at the Seattle offices of the AFSC over a 2-day period, from Tuesday, 24 April through Wednesday, 25 April 2007. SSC chair and REFM Division director Pat Livingston served as chair of the workshop and Liz Conners served as rapporteur. A total of 44 people attended the workshop, reflecting participation from various government agencies, universities, fishing industry groups, and consulting firms.

Tuesday morning's session consisted of six presentations by AFSC and other scientists involved in Pacific cod research. These were as follows:

- Dave Somerton and Dan Nichol (AFSC): Survey catchability/availability
- Bing Shi (AFSC): Estimation of movement and survival rates from tagging data
- Kerim Aydin (AFSC): Can ecosystem models provide a prior distribution for *M*?
- Olav Ormseth (AFSC): Reproductive potential and egg quality: area and maternal effects
- Doug Kinzey (Univ. Washington): Multispecies Aleutian Islands assessment model
- Delsa Anderl (AFSC): Ageing issues and progress

Tuesday afternoon's session began with two more presentations by AFSC scientists, with Jim Ianelli discussing fishery and catch sampling issues and Grant Thompson reporting on modeling issues and progress. The latter presentation addressed several suggestions made by the SSC involving estimation of growth parameters, the natural mortality rate, the trawl survey catchability coefficient, and survey and fishery selectivity schedules. Detailed results were presented for a total of 16 models configured separately for both the BS and GOA, plus another 6 models configured for the BS only. Tuesday afternoon's session concluded with an open discussion which generated suggestions for 10 additional model runs to be made that evening.

The Wednesday morning session began with a free-form discussion regarding the feasibility of a dedicated Pacific cod longline survey. This discussion also addressed the possibility of using data on Pacific cod taken as bycatch in the existing longline survey conducted by the International Pacific Halibut Commission. The Wednesday morning session concluded with a presentation and discussion of results from the model runs made the previous evening.

Wednesday afternoon's session began with a general discussion related to modeling issues. The session concluded with an opportunity for all participants to make suggestions for this year's stock assessments. A detailed summary of the entire workshop, including the list of suggestions for this year's assessments, can be accessed online at: http://www.fakr.noaa.gov/npfmc/misc_pub/PcodwkshpRept407.pdf

By Grant Thompson

Annual Catch Limits Workshop

The AFSC hosted a national workshop to discuss scientific considerations associated with implementing the annual catch limit (ACL) provisions of the Magnuson-Stevens Reauthorization Act of 2006 (MSRA). The workshop, sponsored by the NMFS Office of Science and Technology and Office of Sustainable Fisheries, was held 15-17 May

in Seattle. The need for such a workshop arose as a result of the following new language in the MSRA (italics added).

• Section 302(g): "Each scientific and statistical committee shall provide its Council ongoing scientific advice for fishery management decisions, including recommendations for acceptable biological catch, preventing overfishing, maximum sustainable yield, and achieving rebuilding targets, and reports on stock status and health, bycatch, habitat status, social and economic impacts of management measures, and sustainability of fishing practices."

• Section 302(h): "Each Council shall, in accordance with the provisions of this Act … develop *annual catch limits* for each of its managed fisheries that may not exceed the fishing level recommendations of its scientific and statistical committee or the peer review process established under subsection (g)."

• Section 303(a): "Any fishery management plan which is prepared by any Council, or by the Secretary, with respect to any fishery, shall … establish a mechanism for specifying *annual catch limits* in the plan (including a multiyear plan), implementing regulations, or annual specifications, at a level such that overfishing does not occur in the fishery, including *measures to ensure accountability*."

Because the terms "annual catch limits" and "measures to ensure accountability" are not defined in the MSRA, NMFS is expected to develop regulations to assist Councils in the implementation of the above requirements. Although the development of such regulations provided the context within which the workshop was held, the workshop was not designed to develop specific regulatory recommendations. Rather, the goal was to engage in an interregional, management-science discussion which would explore the breadth of current and potential approaches and the merits of potential follow-up workshops to develop technical guidance. The workshop was attended by NMFS scientists from all of the regional science centers as well as members of many of the Fishery Management Councils. All regions of the country were represented, from the U.S. Virgin Islands to Hawaii. The presentations and discussions revealed the wide variety of approaches used to assess fish stocks and manage fisheries in the U.S. and the difficulty of imposing a common ACL requirement on such a diverse group of management styles.

Four topics were addressed in the workshop: assessment support for ACL determination, quantifying and communicating uncertainty in assessment forecasts, the roles of the scientific and statistical committee and peer review, and data-limited situations. These topics were addressed through presentations by NMFS scientists and follow-up discussion by the workshop participants. Three SSMA Program scientists (Grant Thompson, Rebecca Reuter, and Olav Ormseth) made presentations at the workshop.

Thompson's presentation focused on how to address uncertainty in the context of fishery management. Using an illustration from archery, he showed that a strategy of aiming for a goal (the "bull's-eye") offers better performance than the alternative strategy of achieving a given probability of missing the target entirely. In the context of fishery management, this means that a strategy of maximizing the expected net benefits obtained from fishing offers better performance than the alternative strategy of achieving a given probability of hitting some limit reference point such as a minimum biomass level. Decision theory offers the tools necessary to implement such a strategy. In the decision-theoretic approach, the optimal level of fishing is determined by the statistical uncertainty implied by the data and the level of risk aversion implied by the managers' utility function. Previously, most applications of decision theory to fishery management have been made within a single-species context. In those applications, it is clear that a risk-averse utility function results in an inverse relationship between the level of uncertainty and the optimal level of fishing. Recently, the decision-theoretic approach has been extended to a multispecies context. To date, various types of uncertainty have been considered, including process error (random natural variability), assessment error (imprecise estimates of current biomass), and harvest control (implementation) error.

Reuter worked with stock assessment staff who conduct assessments on non-target and data-poor species to describe recent challenges relating to our current assessment strategies for nontarget species and assemblages in the North Pacific groundfish fisheries. Using examples from past stock assess-

ments for BSAI Other Rockfish and BSAI Other species such as sculpins, octopus, and squid, Reuter outlined the following assessment challenges:

1. Nontarget species are lumped into various species complexes.

2. These complexes are assessed using a single biomass that may reflect only the most abundant species.

3. Lack of data, such as limited catch history, limited biomass data, and limited life history characteristics, makes estimation of reference points difficult.

The main point in the presentation was to discuss whether an annual catch limit is the best way to assess and manage these species and, if not, what other assessment and management strategies can be used under the MSRA.

Ormseth and Jane DiCosimo of the North Pacific Fishery Management Council staff presented a two-part presentation on potential alternatives for assessing nontarget/data-poor species. The first part of their presentation considered whether management approaches designed to maximize/optimize yield are appropriate for species that are not commercial fishery targets. Alternative approaches were discussed, including minimum retention allowances and time/area closures. It was suggested that some form of quota may still be required for species with sensitive life histories, such as sharks. Instead of the traditional ABC/OFL (acceptable biological catch/overfishing level) framework, quotas for these species might be based on measures related to population stability such as those used to describe the status of threatened or endangered species. Of course, establishing such alternatives begs the question of how to determine which species/assemblages qualify for these approaches. One suggestion was to base the decision on the ratio of fishing mortality to total mortality, where a sufficiently high ratio might trigger additional protections (such as quotas) or shift the species into the target species category.

By Grant Thompson, Rebecca Reuter, and Olav Ormseth

AGE & GROWTH PROGRAM

Estimated production figures for 1 January through 30 June 2007.

Species	Specimens
Giant grenadier	359
Greenland turbot	324
Alaska plaice	449
Dover sole	447
Northern rock sole	1,241
Yellowfin sole	496
Bering flounder	258
Walleye pollock	9,047
Pacific cod	3,508
Sablefish	1,224
Atka mackerel	1,629
Pacific ocean perch	1,599
Rougheye rockfish	232
Shortraker rockfish	415

Total production figures were 21,228 with 6,121 test ages and 251 examined and determined to be unageable.

Bomb Carbon and Fish Ageing

During the height of the Cold War in the late 1950s to early '70s, the United States, Russia, and other countries exploded so many nuclear warheads that it significantly raised the amount of C-14 (also known as bomb carbon) in the atmosphere and in the surface layers of the ocean. Because C-14 has a half-life of 5,730 years, its presence remains in earth's air and oceans for millenniums and serves as a timestamp in fish otoliths.

When using bomb carbon to age fish, we match the increase in C-14 radioactivity found in otoliths with recognized amounts in the atmosphere or in biological structures of known age. The essence of this age validation method is as follows: if we know the year a fish was collected and have determined the fish's age in the laboratory (that's fish ageing), then we know when the otolith core was laid down and, accordingly, how much C-14 activity there should be in that core. The Age and Growth Program recently completed its first C-14 study on otoliths from Pacific ocean perch caught in the Gulf of Alaska. The results of our study supported the bomb carbon validation theory based on the validity of the ages we read from Pacific ocean perch otoliths.

By Dan Kimura