Alaska Fisheries Science Center
of the
National Marine Fisheries Service

2007 Agency Report
to the
Technical Subcommittee
of the
Canada-US Groundfish Committee

April 2007

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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2006

A. Agency Overview

Essentially all groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the Resource Assessment and Conservation Engineering (RACE) Division, the Resource Ecology and Fisheries Management (REFM) Division, the Fisheries Monitoring and Analysis (FMA) Division, and the Auke Bay Laboratory (ABL). The RACE and REFM Divisions are divided along regional or disciplinary lines into a number of tasks and subtasks. The FMA Division performs the observer monitoring of the groundfish fleets operating in the North Pacific. The ABL conducts research and stock assessments for Gulf of Alaska groundfish. All Divisions work together closely to accomplish the missions of the Alaska Fisheries Science Center. A review of pertinent work by these groups during the past year is presented below. A list of publications pertinent to groundfish and groundfish issues is included in Appendix I. Yearly lists of publications and reports produced by AFSC scientists are also available on the AFSC website at http://www.afsc.noaa.gov/Publications/yearlylists.htm , where you will also find a link to the searchable AFSC Publications Database. Lists or organization charts of groundfish staff of these four units are included as Appendices II - V.

RACE DIVISION

In 2006 the primary activity of the Resource Assessment and Conservation Engineering (RACE) Division continued to be fishery-independent stock assessment surveys of important groundfish species of the northeast Pacific Ocean and Bering Sea. Regularly

scheduled bottom trawl surveys in Alaskan waters include an annual survey of the crab and groundfish resources of the eastern Bering Sea shelf and biennial surveys of the Gulf of Alaska (odd years) and the Aleutian Islands and the upper continental slope of the eastern Bering Sea (even years).

Two major bottom trawl surveys of groundfish resources were conducted during the summer of 2006 by RACE Groundfish Assessment Program (GAP) scientists; the annual eastern Bering Sea shelf survey and the Aleutian Islands survey. Funding shortages necessitated cancellation of the Bering Sea upper continental slope survey and a 20% cutback in coverage during Aleutian Islands survey. RACE scientists of the Habitat Research Team (HRT) also continued Groundfish habitat-related research.

RACE scientists of the Habitat Research Team (HRT) continue research on essential habitats of groundfish. In FY06, the focus was on investigating the utility of acoustic backscatter as a habitat predictor. Details on the work of the HRT can be found under D. Other Related Studies.

The Midwater Assessment and Conservation Engineering (MACE) Program conducted winter echo integration-trawl (EIT) surveys of midwater pollock abundance in the Shumagin-Sanak area in February 2006 and around Chirikof-Shelikof Strait in March 2006. The Bogoslof Island area was also surveyed in March 2006. A summer survey of pollock on the eastern Bering Sea shelf was conducted in June and July 2006. A fifth year of information was collected on a summer interaction study between commercial fishing and pollock distribution east of Kodiak in late August. MACE scientists also continued research on development of salmon excluder devices for pollock fisheries. MACE staff and other RACE survey personnel continued work on the intervessel calibrations between the *Oscar Dyson* and the *Miller Freeman*.

Guy Fleischer was selected to fill the RACE Deputy Director position formerly held by Russ Nelson, who replaced Gary Stauffer as Director.

For more information on overall RACE Division programs, contact Division Director Russ Nelson at (206)526-4170.

REFM DIVISION

The research and activities of the Resource Ecology and Fisheries Management Division (REFM) are designed to respond to the needs of the National Marine Fisheries Service regarding the conservation and management of fishery resources within the US 200-mile Exclusive Economic Zone (EEZ) of the northeast Pacific Ocean and Bering Sea. Specifically, REFM's activities are organized under the following Programs: Age and Growth Studies, Socioeconomic Assessments, Resource Ecology and Ecosystem Management, and Status of Stocks and Multispecies Assessment. Scientists at AFSC assist in preparation of stock assessment documents for groundfish in the two management regions of Alaska (Bering Sea/Aleutian Islands and Gulf of Alaska, conduct research to improve the precision of these assessments, and provide management support through membership in regional groundfish management teams.

For more information on overall REFM Division programs, contact Division Director Dr. Pat Livingston at (206)526-4173.

FMA DIVISION

The Fisheries Monitoring and Analysis (FMA) Division is responsible for placement of observers on vessels fishing for groundfish species in the U.S. EEZ of the northeastern Pacific Ocean and Bering Sea. Observers collect data, which provide the basis for in-season management of the groundfish fisheries by NMFS, provide a means for evaluating and developing management strategies by the regional management council and NMFS, and are used in the stock assessment process. Observers play important roles in providing information that is critical to the U.S. fishing industry.

During 2006, no foreign vessels were allowed to catch or process fish in the U.S. EEZ off the coast of Alaska. The FMA Division trained and deployed 713 observers to 303 vessels and 24 shore plants in Alaska. These observers spent 36,420 days collecting data in 2006. The Division is responsible for defining the sampling duties and data collection methods used by observers, training of the observers prior to deployment, debriefing of observers upon their return, and editing and managing the resulting data. The catch data are provided to the Alaska Regional Office to assist in management decisions regarding the catches of groundfish and prohibited species. Data are also collected regarding the operations of the groundfish fishery.

For more information on overall FMA Division programs, contact Division Director Dr. Bill Karp at (206)526-4194.

AUKE BAY LABORATORY

The Auke Bay Laboratory (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). In 2006, what was formerly called ABL's "Groundfish Assessment Program" changed its name to the "Marine Ecology and Stock Assessment Program" (MESA), a name which more accurately reflects the varied tasks and research of this group. The MESA Program is primarily involved with research and assessment of sablefish and rockfish in Alaska and with the study of fishing effects on the benthic habitat. Presently, the program is staffed by 15 scientists, including 14 permanent employees and 1 term employee. One Program member, Dean Courtney, has transferred to another NMFS position and will be leaving ABL in summer 2007. Also, two new staff members were added to the program: Cara Rodgveller and Doris Alcorn. Four employees in other ABL programs have also been involved with research on groundfish in the past year.

In 2006 field and laboratory research, ABL's MESA Program, in cooperation with the AFSC's RACE Division, conducted the annual NMFS sablefish longline survey in Alaska. Other field and laboratory work by ABL included: 1) continued juvenile sablefish studies, including routine tagging of juveniles and electronic archival tagging of a subset of these fish; 2) a genetics study to determine species identification and stock structure of young-of-the-year rockfish from offshore waters of the Gulf of Alaska and eastern Bering Sea; 3) a tagging study of Pacific sleeper sharks in southeastern Alaska; 4) epipelagic trawling in offshore waters of southeastern Alaska to sample young-of-the-year rockfish and sablefish; and 5) a study of the reproductive biology of giant grenadier.

Ongoing analytic activities involved management of ABL's sablefish tag database, analysis of sablefish logbook and observer data to determine fishery catch rates, and preparation of five status of stocks documents for Alaska groundfish: sablefish, Gulf of Alaska northern rockfish, grenadiers, Bering Sea and Aleutian Islands sharks, and Gulf of Alaska sharks. Other major analytic activities during the past year were: 1) convening a Rockfish Modeling Workshop at ABL 2) participating in a Center for Independent Experts review of stock assessments of Alaskan rockfish 3) an updated analysis of sablefish migration based on tag release and recovery data through 2005.

Construction was finished in late 2006 at Lena Pt., north of Auke Bay, on a new facility that will house the Auke Bay Laboratory. However, because of technical problems, the actual moving of ABL employees to the new facility has been delayed and is now expected to be completed sometime this summer. A small number of ABL employees will remain at the old ABL location, although most of the office and laboratory space there will be leased to other government agencies. The new name of the Auke Bay Laboratory will be the "Auke Bay Laboratories" to reflect its location at more than one campus.

For more information on overall Auke Bay Laboratory programs, contact Laboratory Director Phil Mundy at (907) 789-6001.

B. Multispecies Studies

1. Research

Diel Sampling of Epipelagic Ichthyofauna in Offshore Waters of the Eastern Gulf of Alaska

During the period 11-21 August 2006, the Auke Bay Laboratory (ABL) used the Alaska Department of Fish and Game research vessel Medeia to conduct research directed at diel sampling of epipelagic ichthyofauna in offshore waters of the Eastern Gulf of Alaska. The general objective of this cruise was to evaluate procedures for establishing a trawl indexing survey for young-of-the-year (YOY) rockfish and sablefish and for juvenile salmon in offshore waters of southeastern Alaska. The project was a continuation of similar research conducted in mid-August 2005. Specific objectives included: 1) conduct an experiment to determine if surface trawling at night is more effective than surface trawling in daytime for capturing YOY rockfish, YOY sablefish, and juvenile salmon; 2) determine the spatial distribution of these three taxa at selected stations along transects off the northern region of southeastern Alaska; and 3) collect physical oceanographic data coincident with the trawl hauls and vessel track to investigate the relationship between oceanographic conditions and the distribution/abundance of fish captured in the trawl. Three programs within ABL collaborated on this study: Marine Ecology and Stock Assessment (formerly ABL's Groundfish Program), Marine Salmon Interactions, and Ocean Carrying Capacity.

Day and night surface trawl sampling with a Nordic 264 rope trawl was successfully completed by the Medeia at each of the six planned stations. These stations were located up to 75 km offshore southeastern Alaska along two transects: Icy Point and Cape Edward. Catches totaled nearly 10,000 fish representing 25 species in 35 hauls. Catch in numbers for the target species of the study were as follows: YOY rockfish, 6,283; YOY sablefish, 276;

and juvenile salmon, 206. YOY rockfish species identification will be made in the laboratory at a later date. Relatively high catches of YOY rockfish were found in several hauls at stations along both transects. The largest catch of YOY rockfish in a single haul was ~3,700 fish, which appears to be the most YOY rockfish ever taken in a pelagic research haul in Alaska. The large numbers of YOY rockfish encountered in this cruise may be an indication of an abundant year class in this region.

There was a marked difference in the catches between day and night. Day tows yielded much higher catches of the target species. In particular, 6,283 YOY rockfish were caught in the day, vs. only 21 at night. These results indicate that for the Nordic 264 rope trawl in 2006, daytime surface tows were much more effective at sampling these species than were surface tows at night.

The 2006 results were very different than results of ABL's 2005 Medeia surface trawling cruise. This was true despite the fact that both cruises were conducted during almost the same dates in August, and they each sampled the same stations along the Icy Point and Cape Edward transects. In contrast to the large catches of YOY rockfish in 2006, a total of only 11 YOY rockfish were caught in 2005. Also, unusual species not commonly found as far north as Alaska, such as Humboldt squid and Pacific sardines, were caught in 2005 but not in 2006. These differences may be explained by the variable oceanographic conditions encountered in each year's cruise, especially water temperature. Summer 2005 was unusually warm in the eastern Gulf of Alaska, and average water temperatures near the surface at stations along our transects were 2.4o C. higher than in 2006.

For more information, contact Dave Clausen at (907) 789-6049.

Bering Sea Crab/Groundfish Bottom Trawl Survey – RACE

The annual crab-groundfish demersal trawl survey of the eastern Bering Sea shelf was completed from May 30- July 27, 2006. A total of 405 stations were sampled, covering nearly 500,000 km^2 from inner Bristol Bay to the shelf edge and from Unimak Pass to 62^o N near St. Matthew Island. The chartered vessels FV *Northwest Explorer* and FV *Arcturus* and this also marked the 25^{th} survey of the 'standard' time series of consistent area, gear, and general sampling protocol.

Biomass estimates for major species indicated a decrease from 2005 for walleye pollock, Pacific cod, and yellowfin sole, and increases for northern rock sole, flathead sole, Alaska plaice, Greenland turbot, arrowtooth flounder, Kamchatka flounder and Pacific halibut. Walleye pollock biomass decreased by almost half in 2006, from 5.13 to 2.85 million t. Arrowtooth flounder increased from about 508 to 608 thousand t. Greater ice cover in the eastern Bering Sea during winter lowered bottom water temperatures to the lowest point since 1999. The average bottom temperature for the 2005 survey, 3.47^oC, was the second highest in the time series compared to 1.87°C for 2006, which was among the five coldest. The lower spring bottom temperatures may have resulted in delayed molting and spawning of female red king crab in Bristol Bay. To prevent a closure in the fishery because of a minimum threshold of red king crab females being unfertilized, 30 stations in Bristol Bay had to be resampled at the end of the survey.

There were 22 special projects and collections undertaken during the 2006 survey and all but two of the projects were from programs inside the AFSC (Table 1). The RACE

Division projects included studies of: 1) gear performance and monitoring; 2) fish behavior in response to light and vessel noise; 3) fish and crab pathology; 4) summer zooplankton biomass; 5) octopus populations, and 5) additional biological sampling of Bering flounder, eelpouts, and miscellaneous fish species. The Resource Ecology and Fisheries Management Division (REFM) and Auke Bay Laoratory (ABL) special studies projects included: 1) fish stomach scans and collections; 2) a seabird survey; 3) biological sampling of sculpins and forage fish; 4) collections of fish prey for stable isotope analaysis, and 5) tissue collections for a DNA-based identification library. The two projects from outside the agency involved halibut otolith, tag and size collections by the International Pacific Halibut Commission (IPHC), and collection of fish specimens for stable isotope analysis rof fur seal prey by the University of Alaska Fairrbanks (UAF).

Data from the 2006 eastern Bering Sea (EBS) continental shelf groundfish bottom trawl survey were error-checked and edited with a final validated data set uploaded to the survey database by mid-September. Survey results of biomass and abundance were presented to the Plan Team members for walleye pollock, Pacific cod, yellowfin sole, flathead sole, arrowthooth flounder, rock sole, rockfish, halibut, Greenland turbot, Alaska skate, and various other non-commercial species for the production of Stock Assessment and Fishery Evaluations.

For further information, contact Bob Lauth, (206) 526-4121.

Aleutian Islands Biennial Groundfish Bottom Trawl Survey - RACE

The fourth in the series of biennial bottom trawl surveys of Aleutian Islands region (AI) groundfish resources was conducted from June 1 through August 11, 2006. The full series of periodic AI surveys dates back to 1980. Prior to establishing a biennial schedule in 2000, these surveys had been done on a nearly triennial schedule by the RACE Division. Surveys conducted prior to 1991 were cooperative efforts involving U.S. and Japanese vessels and scientists. Since 1991 they have been planned and conducted entirely by the RACE Division of AFSC. The primary objective of the surveys is to provide a standardized time series of data to assess, describe, and monitor the distribution, abundance, and biological condition of Aleutian groundfish and invertebrate stocks. Secondary objectives are to collect environmental data (e.g., surface-to-bottom water temperature profiles, etc.) and to make special collections of biological specimens and data requested by scientists from the AFSC or other cooperating research groups.

The 2006 AI triennial survey area stretched over 900 nmi from the Islands of Four Mountains (170º W long.) to Stalemate Bank (170º E long.), including stations on Petrel Bank. In addition, the region between 165° and 170° W long. along the north side of the archipelago is included as the Southern Bering Sea subarea. Stations range in depth from nearshore to 500 m. Sampling was conducted aboard the chartered commercial trawlers *Sea Storm*, which was under charter for 70 days, and the *Gladiator*, which was chartered for 50 days. Sampling began near the Akutan Pass and progressed westward to Adak during the first 25-day leg. For safety considerations, the westernmost portion of the survey was completed at the beginning of the second leg, leaving the central portion for the final leg when the *Sea Storm* was operating alone. Stations were allocated among 45 depth and geographic strata and were preselected randomly from a grid of potential sites overlaying the

survey area. If untrawlable bottom, swift currents, or conflicts with commercial fishing prevented sampling a station, a nearby alternate station was selected. Out of 366 stations assigned to the vessels, 358 were successfully completed, ranging in depth from 32 to 484 m.

Over the total survey area, the most abundant species in 2006 were, in order, Atka mackerel, Pacific ocean perch, northern rockfish, giant grenadier, arrowtooth flounder, walleye pollock, and Pacific cod. Increases in survey-wide estimated biomass since 2004 were observed for Pacific ocean perch by 16% to 667,000 t, northern rockfish by 15% to 218,000 t, and arrowtooth flounder by 94% to 184,000 t. Survey-wide biomass estimates decreased for Atka mackerel by 36% to 741,000 t, giant grenadier by 22% to 193,000 t, pollock by 69% to 113,000 t, and cod by 19% to 93,000 t. Results have been supplied to stock assessment authors for updating assessment reports for the North Pacific Fisheries Management Council.

Biological data and specimens were collected from a wide variety of groundfish and invertebrates. Over 96,000 length observations were recorded from 52 species. Length and individual weight measurements were recorded from almost 10,600 fish from 50 species. Over 7,800 pairs of otoliths were collected from 20 species, including 3 species of sculpin that were sampled for the first time this year.

For further information please contact Mark Wilkins, (206) 526-4104.

Groundfish Systematics Program - RACE

James Orr and Duane Stevenson continue working on the taxonomy and systematics of several families of fishes, most recently skates, snailfishes, rockfishes, sculpins, eelpouts, manefishes, and deep-sea anglerfishes. Both participated in meetings of the American Society of Ichthyologists and Herpetologists in New Orleans and the Charles Henry Gilbert Ichthyological Society in Newport, where they presented papers on skate distribution and systematics. Orr's work with Sharon Hawkins of Auke Bay Laboratory on the recognition, identification, and nomenclature of *Sebastes melanostictus* will be completed with the examination of important Japanese type specimens, which will be examined during an extended stay as a visiting professor to Kyoto in January-March 2007. Stevenson's paper synonymizing the name *Stlegicottus xenogrammus* with *Rastrinus scutiger* is in press and he presented a paper on his work at the annual meeting of the Gilbert Ichthyological Society. His range extension and review of the morphology of *Caristius* in the eastern North Pacific with lead author Dave Csepp of the Auke Bay Lab is in press. Stevenson also had a manuscript published in Copeia in 2006 describing a new species of eelpout, *Lycodes akuugun*, from the Aleutian Islands. This species is currently known from less than 20 specimens, all collected on the RACE Division's Aleutian Islands bottom trawl surveys. Duane is nearing completion of another manuscript detailing a worldwide taxonomic revision of the eelpout genus *Bothrocara* with Eric Anderson and Gento Shinohara. The center of distribution of this genus appears to be the eastern Bering Sea, where 6 of the 8 recognized species have been collected on NMFS bottom trawl surveys. One of these species, the recently described *Bothrocara nyx*, was recently described from the Bering Sea slope and is apparently endemic to that region. Duane has a third manuscript in internal review that describes emerging patterns of species richness and density in the skates of Alaska based on groundfish survey data.

Over the past several months, Orr, Stevenson, and Jerry Hoff have been working with Alaska Sea Grant to finalize the Field Guide to the Sharks, Skates, and Ratfish of Alaska. The guide will be released for sale to the public in summer 2007. It will include anatomical diagrams, dichotomous keys to the adults and egg cases of Alaska's chondrichthyans, color photos, range maps and tooth illustrations. This publication is based primarily on data collected during the AFSC's bottom trawl surveys, as well as the authors' visits to research collections in Japan and Russia. The target audience includes professional fish biologists, fisheries observers, commercial fishermen, students and educators, naturalists, and divers. The primary goal of this publication is to facilitate the effective stewardship of Alaska's chondrichthyan populations by making species-level identification of sharks, skates, and ratfish accessible to professionals and laymen alike. Popular Alaskan fish artist Ray Troll has been commissioned to produce the cover art for the guide.

For further information, contact Dr. James Orr, (206) 526-6318.

Recruitment Processes Program

Scientists of the Recruitment Processes Program conduct a number of studies investigating distribution, abundance, and size structure of larval and juvenile groundfish in the Gulf of Alaska and Bering Sea. In the Bering Sea, species under investigation include northern rock sole and Greenland halibut; flatfishes, Pacific cod, walleye pollock and capelin are being studied in the Gulf of Alaska.

Bering Sea northern rock sole - A study of distribution, abundance and size structure of northern rock sole (*Lepidopsetta polyxystra*) larvae was conducted on the eastern Bering Sea shelf. Highest abundances of larvae were collected in Unimak Pass and northeast of Unimak Island. Larval abundance and size varied with depth. Highest abundances were at depths of 10-30 m during the day, and larger fish appeared to migrate from below 20 m to 0-10 m at night. There was evidence of multiple spawning locales and larval dispersal pathways that were depth- and area-specific. Dispersal of northern rock sole larvae at depth (>10 m) is probably more affected by factors that modulate geostrophic flow than wind-driven surface currents.

Current work on northern rock sole larvae in the Bering Sea (Stockhausen et al.) uses the Dispersal Model for Early Life History Stages (DisMELS) model to simulate egg and larval dispersal. The DisMELS model utilizes a 3-D oceanographic model based on the Regional Oceanographic Modeling System for the northeast Pacific (NEP ROMS) but also incorporates individual behavior (vertical migration). Goals of this project are to generate quantitative indices of predicted recruitment from 1978 to 2007 as alternatives to OSCURS predictions.

Bering Sea Greenland halibut - A project funded by the North Pacific Research Board has begun that investigates the transport pathways from spawning to potential nursery locations of Greenland halibut eggs and larvae in the eastern Bering Sea. Goals of the project are to assess Greenland halibut (1) spawning locations, (2) egg and larval drift pathways, (3) egg buoyancy, (4) larval and juvenile feeding and growth patterns, and (5) vertical egg distribution. A research cruise was undertaken in May, 2006 to begin assessing horizontal,

vertical distribution of larvae, and future cruises are planned for May, 2007 (Pribilof Canyon & Pribilof Island vicinities) and February, 2008 (Bering Canyon vicinity). We are collaborating on this project with Dr. Lorenzo Ciannelli (Oregon State University).

Gulf of Alaska walleye pollock and capelin - A research study was undertaken in 2005 (with partial funding by the North Pacific Research Board) to examine the effects of local hydrography on the distribution and diets of capelin and young-of-the-year walleye pollock in Barnabus trough, Gulf of Alaska. Physical oceanographic sampling indicated a mid-trough front separating two different water masses, with mixed schools of age-0 pollock and capelin where found offshore in cool, high-salinity water, and capelin (mixed with jellyfish) inshore of the front in warmer, low-salinity water. Diet analyses indicated that age-0 pollock consumed primarily euphausiids and large copepods offshore, while capelin consumed mostly small calanoid copepods and larvaceans inshore and offshore. Another cruise is planned for this September on the NOAA Ship *Miller Freeman*.

There have been a number of field and laboratory studies completed on the ecology of walleye pollock in the Gulf of Alaska. In a report by Porter and Bailey (in press) they showed that early hatching larvae are more vulnerable to predation by invertebrate predators than those that take longer to hatch. A paper by Dougherty et al., (accepted) examined growth and hatchdate variability of juvenile walleye pollock caught in the Shumagin Is region, and showed that resident juveniles originate from spawning in Shelikof Strait. A report by Ciannelli et al., (in press) examined the locations of pollock spawning in the GOA from the abundance of pollock eggs in the ichthyoplankton. They found that persistent spawning occurs in several nearshore areas, but spawning in offshore regions is variable.

Gulf of Alaska Pacific cod - A study examining the distribution, abundance and feeding of juvenile Pacific cod in nearshore habitats was conducted near Kodiak Island, Alaska (Abookire et al., 2007). Beach seines were used to collect individuals, and associated environmental measurements (depth, water temperature, salinity, sediment grain size, and percent cover by emergent structures) were collected. Density of juvenile Pacific cod was highest in areas of moderate depth (15-20 m) and positively and linearly related to percent cover by sea cucumber mounds and to salinity. Presence of eelgrass and macroalgae had no significant affect on cod distribution. Diets consisted mainly of small calanoid copepods, mysids, and gammarid amphipods and were significantly related to depth and percent mud.

Gulf of Alaska Flatfishes - Several projects have been completed examining ontogenetic changes in the distribution of stages of offshore spawning flatfishes. Distribution shifts of Dover and rex sole were examined in a report by Abookire and Bailey (2007). Dover and rex sole were compared with arrowtooth flounder and Pacific halibut in Bailey et al. and retrospective research into the association between larval fish assemblages and their environment continue (Doyle et al., 2006).

For further information, contact Dr. Jeff Napp, (206) 526-4148.

Fisheries Behavioral Ecology Program - RACE

The Fisheries Behavioral Ecology Program based in Newport, Oregon conducts experimental research designed to understand the role that behavior plays in regulating distribution, abundance growth, and survival of fish species and their interactions with fishing methods and gear. The goal of the Program is to provide the critical information needed to improve survey techniques, to improve predictions of population abundance and survival, and to conserve populations of economically significant marine resource species and their habitats. Research conducted during 2006 continued under long-term research themes related to bycatch stress and basic studies in fish ecology relevant to the performance of fishing gear, definition of essential habitat, and recruitment processes.

Experimental Bycatch Studies - Bycatch studies in AFSC's Fisheries Behavioral Ecology Program fall into two main categories: 1) the fate of fish which are discarded after their arrival on the deck, and 2) the fate of fish which escape trawl gear at depth through cod-end meshes. Laboratory studies have identified key principles which control mortality; integrating analysis of injury, behavior, and plasma constituents with observed mortality. In general, capture and environmental stressors interact to produce physical injury, behavior impairment, and immediate and delayed mortality. High incidence of mortality in smaller fish indicates that the practice of high-grading in fisheries is counter-productive for stocks and should be generally restricted.

Behavioral impairment and mortality in fish escapees and discards from fishing operations may be predicted directly from measurements of reflex actions (Davis & Ottmar, 2006). A major advantage of this technique is that routine long term holding of fish in cages or tagging and recapture are not needed for determination of mortality. Reflex impairment in walleye pollock, sablefish, coho salmon, northern rock sole, and Pacific halibut was significantly related to delayed and total mortality in biphasic relationships described by sigmoid curves. These relationships are termed RAMP (reflex action mortality predictors). RAMP initially increased without concomitant mortality, and then continued to increase as mortality appeared and increased. The essence of the approach is to find ways to stimulate reflex actions consistently in control fish and then measure reflex impairment in stressed fish. Reflex impairment can be observed after capture or escape in either free swimming fish or restrained fish. For free swimming fish, impairment of orientation, position, and startle responses to visual and sound stimuli can be observed and recorded in sea cages or tanks on board ships. For restrained fish, impairment of body flex, operculum closure, mouth closure, gag response, and vestibular-ocular response can be observed. Other reflex responses may also be present in species of interest. Measurement of reflex impairment may be a powerful tool for expanding the scope and replication of fishing experiments in the field and for comparing bycatch mortality among various fishing practices and fisheries. RAMP may also be used in any context in which rapid assessment of fish welfare is needed, e.g., aquaculture, fish transport, stock enhancement, holding for experimentation. The RAMP method is being expanded to crab and other invertebrate bycatch species in future research.

Surveys with underwater vehicles - Underwater vehicles including submersibles, ROVs and towed camera systems are used increasingly to assess the abundance and distribution of demersal fishes, particularly in structurally complex habitats. It is often assumed that visual survey data have less inherent bias than sampling with conventional

survey gear. To evaluate potential biases in surveys employing underwater vehicles, the AFSC Fisheries Behavioral Ecology Program conducted an analysis of reactions by demersal marine fishes. Almost all of the 46 fish observed respond to underwater vehicles in some way, depending upon operational variables including vehicle type, speed, light and sound levels. Direct responses were common, and some fishes respond indirectly, by attraction to sediment disturbance and prey species gathered in artificial lights.

A simple conceptual model was developed to evaluate relationships between stimulus intensity, distances from the vehicle where reactions occur, and survey bias. While light level and vehicle speed have been explored experimentally in a few cases, much remains to be learned about how reactions and biases vary among species and age classes, and among different vehicles and operating conditions. It was concluded that surveys need to be conducted using methods that minimize variation in vehicle operation and that vehicle time be devoted specifically to manipulations of operating conditions to evaluate bias quantitatively. FBEP is currently conducting laboratory experiments to evaluate the effects of light on fishery species including rockfishes, sablefish and halibut.

For further information, contact Dr. Allan Stoner, (541) 867-0165.

Age and Growth Program - REFM

The Age and Growth Program of the REFM Division serves as the Alaska Fisheries Science Center's ageing unit for groundfish species. The program currently consists of a biometrician, age validation researcher, IT/data specialist, and 9 age readers. Ages are usually determined from otoliths, but scales, finrays and vertebrae are sometimes used. The protocols governing age determination at the AFSC have recently been documented by (Kimura and Anderl, 2005), whose paper is now available on the Age and Growth website.

Data provided by the program are used in stock assessment modeling, which contributes to the estimation of the allowable catch of many commercially important groundfish species. These species include walleye pollock, Pacific cod, sablefish, Pacific ocean perch, northern, rougheye, and dusky rockfishes, Atka mackerel, yellowfin sole, rock sole, rex sole, and misc. sole and rockfish species. Increasingly, the program is ageing "minor" species, which either are possible candidates for commercial harvest, or may be important in monitoring the broader ecosystem. Examples of these include the giant grenadier, big and longnose skates, and several sculpin species.

Research in the Age and Growth Program in 2006 has focused on the following areas:

1. Craig Kastelle and Dan Kimura are also completing a manuscript documenting results on C-14 age validation of Pacific ocean perch from the Gulf of Alaska. Although some outliers exist, the bomb carbon method provides strong support of the POP ageing criteria used at the AFSC, and proposes new methods for data analysis. Papers on the application of C-14 to other species will follow.
2. Dan Kimura, Delsa Anderl, and Betty Goetz are completing a manuscript analyzing 17 years of edge type data collected by age readers on 9 different species. These data support the hypothesis of seasonal growth in 7 of these species.

3. Charles Hutchinson and Delsa Anderl are documenting methods being developed for the ageing of giant grenadier (*Albatrossia pectoralis*)." This species is turning out to be difficult to age, and is hoped that we can validate our ageing methods using C-14.
4. Also, Charles Hutchinson and Betty Goetz have been involved in standardizing the ageing of shortraker rockfish, so that ageing can be done on a production, rather than a research basis. Again, ageing of this species is proving difficult and we hope that C-14 can be used to improve our method of ageing and eventually validate ageing criteria for this species.
5. Jon Short recently developed a new online website for direct users of age data from the Age and Growth Program. This database is meant to show the progress of samples as they are processed by age readers. The purposes of this database are to allow users to track their requests, and to make the internal operations of the Age and Growth Program more transparent. The site can be found using the link http://www.afsc.noaa.gov/REFM/Age/ageingrequests.htm. When queried, this database will display three groups of samples:

   a. The first group of samples is "Requests in Queue." These are samples which have been requested, but have not been started by age readers.

   b. The second group of samples is "Currently Ageing." These are samples in the process of being read. It is possible to view the total sample sizes and the sample size that has been read. Don't forget samples must be tested by a second age reader, and the test results reconciled before samples are released to users.

   c. The third group of samples is "Released Collections." These are samples have completed processing and have released to the users. This list includes recently released samples and samples that have been released during the previous calendar year.

For further information contact Dr. Daniel K. Kimura (206) 526-4200.

Resource Ecology and Ecosystem Modeling - REFM

2007 TSC Report – Multispecies Studies

Resource Ecology and Ecosystem Modeling

Multispecies, foodweb, and ecosystem modeling and research are ongoing. Documents, symposia and workshop presentations, and a detailed program overview are available on the Alaska Fisheries Science Center (AFSC) web site at:
http://www.afsc.noaa.gov/REFM/REEM/Default.php.

Groundfish Stomach Sample Collection and Analysis
The Resource Ecology and Ecosystem Modeling Task (REEM) continued regular collection of food habits information on key fish predators in the North Pacific. Collection of groundfish stomach samples is primarily through the RACE bottom trawl and echo-integration/trawl

surveys. Additional samples that broaden our spatial and seasonal coverage are obtained through the Observer Program and through coordinated studies with other agencies. In 2006, REEM collected samples and data during bottom trawl surveys of the Aleutian Islands and eastern Bering Sea. Stomach samples were also collected during surveys by other agencies and by Observers during fishery operations. In total, 5,984 stomachs were collected from the eastern Bering Sea and 2,074 stomachs were collected from the Gulf of Alaska and Aleutian Islands. Laboratory analysis was conducted on 8,452 fish stomachs from the Bering Sea and 2,601 fish stomachs from the Gulf of Alaska and Aleutian Islands. At-sea analysis was conducted on 780 fish stomachs from the Bering Sea and 1,402 fish stomachs from the Aleutian Islands. The REEM predator-prey database was updated with 50,032 records in 2006. Complete database details can be found at http://www.afsc.noaa.gov/REFM/REEM/data/default.htm.

Predator/Prey Interactions and Fish Ecology

REEM examines patterns in predator-prey data based on predator species, predator size and spatial distribution, and trends in seasonal and interannual predator-prey interactions are analyzed. Such food habits data is a key input into REEM multispecies and ecosystem modeling efforts, which rely on diet composition matrices from these data in order to produce yearly estimates of predation mortality for key species such as walleye pollock. Recent additions to the series of REEM food habits reports for the Gulf of Alaska (http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-164.pdf) and the eastern Bering Sea (http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-158.pdf) are now available. The food habits of over 40 fish species are described in these two reports. The reports indicate that internannual comparisons of the diet composition of major predatory species often show large differences. For example, arrowtooth flounder in the Gulf of Alaska consumed a greater percentage of pollock and osmerids (primarily capelin) in 2001 than in 1999. Predator/prey data is also used by REEM to estimate the biomass of economically important species consumed by groundfish predators. For example, REEM recently updated the biomass of snow crabs consumed by groundfish predators in the eastern Bering Sea.

Multispecies and Ecosystem Modeling

A database of life history characteristics of Alaska groundfish, as determined by extensive literature review, was made available to the public at http://access.afsc.noaa.gov/reem/LHWeb/index.cfm. These life history parameters will be a key to developing the next generation of multispecies models. Modeling results, including trends of estimated population consumption by key groundfish in the eastern Bering Sea, were also made available to the public. These results are from MSVPA (multispecies virtual population analysis) (http://www.afsc.noaa.gov/refm/reem/models/MSVPA.htm) and the multispecies statistical model (http://www.afsc.noaa.gov/refm/reem/models/MSM.htm).

Assessing interactions between fisheries and marine mammals remains a critical national and international issue, and ecosystem models continue to enter this debate. In making policy decisions based on these models, it is important to evaluate the ecological assumptions underlying each model. For example, how do predators react to changes in prey in the model and in the real ecosystem? Do they forage over separate areas, each selecting from a range of prey choices or do they compete directly in local “hotspots” for individual prey types? The answer may differ by predator, by ecosystem, or especially by local conditions. Current multispecies and ecosystem models tend to make a single assumption on the scale of competition

and this may lead to biased results: the "complexity" of predator/prey interactions may be best evaluated by using a wide range of statistically validated models and assumptions for any particular predator/prey interaction.

REEM is collaborating with SSMA and University of Washington (UW) researchers to incorporate trophic interactions within a Management Strategy Evaluation (MSE) for Gulf of Alaska pollock. REEM is providing information on potential changes in pollock mortality under different ecosystem conditions in a streamlined format that allows SSMA and UW scientists to minimize computational complexity within the MSE. This summer, we distilled results of thousands of Gulf of Alaska ecosystem model runs into functional relationships between pollock mortality and predator biomass which considered different levels of pollock biomass and ecosystem-wide primary productivity. Preliminary results show fairly strong relationships between the biomass of a handful of key predators and total pollock mortality; the relationship is especially strong between juvenile pollock mortality and arrowtooth flounder biomass. In general, these results suggest that pollock mortality increases with predator biomass more quickly and to a higher level when pollock biomass is relatively low , and that individual predators affect pollock mortality to a lesser extent when pollock biomass is high. REEM continues to refine this work in collaboration with SSMA and UW to provide a full range of ecosystem interactions for analysis within the Gulf of Alaska pollock MSE.

The AFSC is developing a scientific framework for providing ecosystem-based advice for the management of groundfish fisheries. This framework has three main goals for protecting the ecosystem attributes: 1) maintain predator/prey relationships, 2) maintain energy flow and balance, and 3) maintain diversity. This framework includes using multispecies models (biological and technological interactions) for developing statistically rigorous multispecies forecasts. In particular, we have developed a multispecies virtual population analysis and a multispecies forecasting model for the eastern Bering Sea. Unfortunately, these models lack statistical assumptions obstructing the inclusion of uncertainty into multispecies model parameter estimation. Therefore, REEM recently developed a simple version of a multispecies statistical model (MSM) to show that it is possible to incorporate MSVPA predation equations into a statistical catch-at-age model. The MSM focuses on two species, walleye Pollock and Pacific cod. A more elaborate version of this model has been set up in the AD model builder platform (ADMB).

The integration of multispecies and ecosystem modeling results into the Stock Assessment and Fishery Evaluation (SAFE) was substantially expanded in 2006, especially in the ecosystem assessment and Bering Sea walleye pollock ecosystem considerations sections. In particular, forage fish biomass trends from bottom trawl surveys for the last 24 years in the Bering Sea were summed using catchability coefficients ('q') calculated from the Bering Sea ecosystem model. The results show two notable features: First, forage fish seemed to show an "ecosystem response" to decreased pollock biomass in the early 1990s, with the decrease in pollock being followed by an increase in shrimp, capelin, and other forage species. This increase may be due to prey release or alternating climate conditions favoring different suites of species: Second, forage fish biomass seems to have dropped abruptly after 1998, and the last 7 years (1999-2006) have shown the lowest biomass of non-pollock forage since the time series began. Another trend of note in the Bering Sea has been the increase in arrowtooth flounder in recent years; analysis of this trend, particularly with respect to its impact on pollock, is ongoing.

Seabird - Fishery Interaction Research

The annual estimates of seabird bycatch have been posted on the AFSC website seabird page. These estimates provide bycatch numbers by certain species groups or species from 1993 through 2004 for all gear types (longline, pot, trawl) in Alaskan waters. Numbers are provided by Fishery Management Region as well. The estimate of seabird bycatch is completed by NMML staff each year and provided to the REEM Program. Two data sources are necessary for these estimates to be completed: those provided by groundfish observers and managed by the Fishery Monitoring and Analysis Division and the fisheries catch database maintained by the Alaska Regional Office's Sustainable Fisheries Division. While data are provided for all gear types, much of the focus has been on longline fisheries. Overall seabird bycatch has dropped in those fisheries from a high of more than 25,000 birds in 1998 to current levels of less than 5,000 birds. This is primarily due to the voluntary adoption of paired streamer lines by the freezer-longliner fleet in 2002 after a Washington Sea Grant study showed that paired streamer lines were the most effective seabird deterrent measure. Paired streamer lines were required for all vessels over 55 ft through regulatory rulemaking completed in February 2004. Prior to the extensive use of paired streamer lines in 2002, the average annual bycatch of seabirds in the combined Alaskan demersal groundfish fleet was 15,888 birds. Since then (2002 -2004) the average has been 4,910, a 70% reduction.

Conducting and coordinating seabird surveys is an important focus for the AFSC's seabird program. Two types of surveys were worked on. The first is the stationary survey format developed by Washington Sea Grant for longline cruises in 2004. This format was expanded to all research and charter cruises conducted by the AFSC for 2006. Staff also coordinated with the NWFSC to implement the surveys on the West Coast charter cruises. These surveys now cover NOAA Fisheries research and charter cruises from southern California, up the west coast, and throughout Alaskan waters. The second is the strip-census seabird survey. Staff have worked very closely with the USFWS Migratory Bird Division to conduct strip-census seabird surveys on appropriate platforms. This work will add to the extensive survey work completed in the 1970's and early 1980's and will ultimately be made available to researchers through the North Pacific Pelagic Seabird Database (USGS).

Two analyses relevant to the short-tailed albatross biological opinion are nearing completion. A risk assessment of short-tailed albatross interactions with trawl vessels and a threshold analysis for short-tailed albatross incidental takes in the Alaskan groundfish fishery are being conducted by UW scientists. These analyses are under the direction of the AFSC Seabird Program through funds provided by the National Seabird Program.

Ecosystem Considerations

REEM coordinated the annual production of the Ecosystem Considerations section of the Stock Assessment and Fishery Evaluation for the North Pacific Fishery Management Council. It is utilized to advance our understanding of marine ecosystem dynamics and deliver ecological, oceanographic, and climatic indices to stock assessment scientists and managers. The report includes an ecosystem assessment, updated status and trend indices, and ecosystem-based management indices and information for the Bering Sea (BS), Aleutian Islands (AI) and the Gulf of Alaska (GOA) ecosystems. Integration of information regarding ecosystem status and trends and the use of models to predict possible future ecosystem states using an indicator approach constitutes the framework of a BS/AI and GOA ecosystem assessment. Annual updates of

historical trend and present status of various ecosystem indicators are performed by internal development and update of indicators and communicating with the diverse scientific community that is involved in climate, protected species, sustainable fisheries, and ecosystem research. The purpose of the third section, Ecosystem-based Management Indices and Information, is to provide either early signals of direct human effects on ecosystem components that might warrant management intervention or to provide evidence of the efficacy of previous management actions. The information in the Ecosystem Considerations report is utilized by the NMFS Alaska Regional Office and the North Pacific Fishery Management Council to evaluate the environmental impacts of various Fishery Management Plan alternatives. A new website has been developed that provides access to the contributions as well as to data time series summarized in the report: http://access.afsc.noaa.gov/reem/ecoweb/Index.cfm.

Major environmental trends last year included the reversion to relatively cold conditions in the Bering Sea during the winter of 2005/2006, which resulted in an extensive cold pool in the summer of 2006. This cold trend, however, was regional in nature and a continued warming trend with reduced ice extent has been documented through much of the Arctic. Temperature conditions in the Gulf of Alaska were the warmest on record in 2005 (information for 2006 was not available). A major conclusion from the analysis of various trends is that no apparent adverse effects of fishing on the ecosystems have been documented to date. Concerns about high bycatches of salmon in the Bering Sea pollock fishery, however remain, and these are being addressed by the Council.

An example of an updated and reanalyzed index is the trophic level of the catch. The trophic level of the catch and the Fishery in Balance (FIB) indices have been monitored in the BS, AI, and GOA ecosystems to determine if fisheries have been "fishing-down" the food web by removing top-level predators and subsequently targeting lower trophic level prey. The FIB index indicates whether trophic level catch trends are a reflection of deliberate choice or of fishing-down the food web. This index declines only when catches do not increase as expected when moving down the food web (i.e., lower trophic levels are more biologically productive), relative to an initial baseline year. Although there has been a general increase in the amount of catch since the late 1960s in all three areas of Alaska, the trophic level of the catch has been high and relatively stable over the last 25 years. Unlike other regions in which this index has been calculated, such as the Northwest Atlantic, the FIB index and the trophic level of the catch in the EBS, AI, and GOA have been relatively constant and suggest an ecological balance in the catch patterns.

For more information about REEM research, please contact Kerim Aydin at (206)526-4225.

2. Stock Assessment

Status of Stocks and Multispecies Assessment Task - REFM

The Status of Stocks and Multispecies Assessment Task is responsible for providing stock assessments and management advice for groundfish in the North Pacific Ocean and the Bering Sea. In addition, Task members conduct research to improve the precision of these

assessments, and provide technical support for the evaluation of potential impacts of proposed fishery management measures.

During the past year, stock assessment documents were prepared by the Task for the Gulf of Alaska and Bering Sea/Aleutian Islands Groundfish Plan teams of the North Pacific Fishery Management Council and for the groundfish management team of the Pacific Fishery Management Council.

Assessment scientists provided analytic assistance on many current fisheries management issues. These included: 1) identification and prioritization of research activities intended to improve groundfish stock assessments; 2) Developing a FMP Amendment to define overfishing for the crab stocks of the Bering Sea 3) completed Aleutian Islands pollock, rockfish and Atka mackerel cooperative research projects with industry ; 4) convened workshops on recruitment with REFM/ABL/RACE, FOCI and PMEL, a PFMC B_0 workshop (by Martin Dorn Chair of Groundfish Subcommittee of SSC) and a Lowell Wakefield Symposium (organized by Jim Ianelli) 5) initiated a breakout of species in the "other species" category of the FMP for improved management, and 6) various task members participated in numerous national and international committees and workshops on a variety of issues.

Sarah Gaichas, currently a member of the Resource Ecology and Ecosystem Modeling program, completed her Doctoral Dissertation (University of Washington) titled: Development and Application of Ecosystem Models to Support Fishery Sustainability: A case study for the Gulf of Alaska. A summary of her dissertation can be found at: http://www.afsc.noaa.gov/Quarterly/jas2006/jasfeaturelead.htm

The Fishery Interaction Team (FIT), a part of the Status of Stocks and Multispecies Assessment Task, in the REFM Division, conducts studies to determine whether commercial fishing operations are capable of impacting the foraging success of Steller sea lions either through disturbance of prey schools or through direct competition for a common prey. The present research focus is on the three major groundfish prey of sea lions: walleye pollock, Pacific cod and Atka mackerel.

FIT investigates the potential effects of commercial fishing on sea lion prey in two ways. First, by conducting field studies to directly examine the impact of fishing on sea lion prey fields and to evaluate the efficacy of trawl exclusion zones. FIT research examines the hypothesis that large-scale commercial fisheries compete with sea lion populations by reducing the availability of prey in relatively localized areas. Since 2000 FIT has been conducting field studies to examine the impact of fishing on sea lion prey fields in all three major Alaska regions: the Gulf of Alaska, Bering Sea and Aleutian Islands.

The second way that FIT investigates the potential effects of commercial fishing on sea lion prey is by studying fish distribution, behavior and life history at spatial scales relevant to sea lion foraging (tens of nautical miles). This scale is much smaller than the spatial scales at which groundfish population dynamics are usually studied and at which stocks are assessed. This information is needed to construct a localized, spatially-explicit model of sea lion prey field dynamics that can be used to predict spatial and temporal shifts in the distribution and abundance of sea lion prey and potential effects of fishing on these prey fields.

FIT researchers collaborate with other AFSC scientists who are studying Steller sea lions and their prey, such as scientists in the Resource Ecology and Ecosystem Modeling program and the National Marine Mammal Lab. For more information on the FIT program, contact Dr. Libby Logerwell or access the following web link: http://www.afsc.noaa.gov/REFM/Stocks/fit/FIT.htm

For further information on the SSMA task group, contact Dr. Anne Hollowed (206) 526-4223.

3. Management

Economics and Social Science Research Program – REFM

The Economics and Social Science Research Program of the REFM Division has beeon focusing on the following projects during 2006:

- **The Demand for Halibut Sport Fishing Trips in Alaska** - Dan Lew
  For further information, contact Dan.Lew@NOAA.gov
- **Integrating Trip and Haul-Level Groundfish Fishing Data** - Alan Haynie
  For further information, contact Alan.Haynie@noaa.gov
- **Groundfish Market Data Collection and Translation** - Ron Felthoven
  For further information, contact Ron.Felthoven@NOAA.gov
- **Collecting Regional Economic Data for Alaska Fisheries** - Hans Geier and Chang Seung *For further information, contact Chang.Seung@NOAA.gov*
- **Two Phases of an Integrated Economic-Ecosystem Modeling Project Completed** - Chang Seung *For further information, contact Chang.Seung@NOAA.gov*

- **Gulf of Alaska Halibut IFQ and Small Remote Fishing Communities** - Dan Lew and Jennifer Sepez *For further information, contact Jennifer.Sepez@NOAA.gov*
- **Through a Cod's Eye: Exploring the Social Context of the BSAI Pacific cod Fishery** - Emilie Springer *For further information, contact emilie1@u.washington.edu*

For further information or if you have questions about the Economic and Social Sciences Research Program please contact Dr. Ron Felthoven (206)-526-4114.

C. By species, by agency

1. Pacific Cod

a. Research

Larval recruitment

In 2006, the Fisheries Behavioral Ecology Program began a multi-year research program with support from the North Pacific Research Board to develop spatially-explicit models of growth potential for Pacific cod larvae and juveniles in the Bering Sea with respect to climate change. The project was designed to be a true collaborative effort among modelers and laboratory scientists as a means of generating the necessary data and model framework to examine environmental-survival/growth interactions. Research was initiated in 2006 with the first shipment of fertilized eggs from Kodiak to Newport to examine the effects of temperature on developmental rate, energy allocation, growth, and mortality in eggs and larvae. Pacific cod eggs survived and hatched at all the temperatures tested, but hatching success was significantly lower at 0°C relative to temperatures ≥ 2°C. The effects of temperature on egg development are being examined by lipid/fatty acid analysis.

The consequences of eggs hatching early and late to larval growth and survival were further examined by following cohorts of early and late-hatching larvae to 50% mortality, i.e., the 'Point-of-No-Return', the period at which remaining larvae are too weak to feed even if prey

were available. In all temperature treatments, early hatching larvae were smaller but had more lipid reserves and survived longer after hatch in the absence of food than late hatching fish. Additional experiments are designed to examine the interactions of food and temperature on the vital rates of post-feeding larval and juvenile stages of Pacific cod.

Currently, the data from Pacific cod larval experiments are being incorporated into models using field data on larval and juvenile distributions, temperature and primary productivity (SeaWiFS/MODIS Aqua data) to examine population-level consequences of changing environmental conditions in the North Pacific. This project component is being conducted in a collaborative effort between AFSC's Fisheries Behavioral Ecology Program and Oregon State University oceanographers, and is anticipated to be finished in 2008.

Juvenile habitat

Studies of habitat associations in age-0 Pacific cod were initiated by the AFSC Fisheries Behavioral Ecology Program in Kodiak during 2006 using seines, trawls and baited cameras. Seines provided physical samples for collections in shallow water whereas the baited cameras were effective in determining relative abundance in a wide range of habitats including deep water, seagrasses and rocky areas. Age-0 fish were abundant in nearshore macrophytes (*Laminaria* and *Zostera*) particularly during the earliest post-settlement stages, and then expanded into open habitats at greater depths with size during the first summer. Laboratory experiments showed that preferences for structurally complex habitats are strongest when potential predators are present.

Age-0 Pacific cod were captured in Kodiak nursery sites and shipped to the Newport laboratory for experiments on potential growth. Following laboratory acclimation, fish were reared under *al libidum* feeding conditions for 2-3 months at four temperatures between 2 and 13^{o}C. Subsequent experiments will test growth at additional temperatures and examine the thermal effects on consumption rate.

For further information, contact Dr. Allan Stoner, (541) 867-0165.

b. Stock Assessment

BERING SEA/ALEUTIANS

The present assessment is a substantial revision of last year's assessment, incorporating an analysis of a combination of model runs with different configurations. The 2006 EBS shelf bottom trawl survey resulted in a biomass estimate of 518,000 t, down 14% from the 2005 estimate (604,000) and the lowest observed for the 24 year time series. The 2006 Aleutian Islands estimate of 92,500 t was 19% lower than the 2004 estimate.

The following models were evaluated. Model 0 is last year's preferred model, where catchability was fixed (Q = 1.0). Eight alternative models were tested (Models A1, A2, B1, B2, C1, C2, D1, D2) with some features in common including estimation of shelf trawl survey catchability (Q; prior mean = 1.0, CV = 0.3) and separate estimation of Q for the pre-1982 and 1982-and-later trawl surveys. The eight alternative models differed in whether longline surveys were included, the functional form of selectivity, and whether priors were given full (1.0) or partial (0.5) weight. The two selectivity functions were the double-logistic (8 parameters) and the double-normal (4 parameters). The combinations of these eight models form a factorial design.

The following criteria was proposed for selecting the preferred model: 1) reasonable selectivity for a trawl survey (no pronounced "kink" in the shape); 2) data are validated and ready for use (e.g. longline survey data); 3) model converges well and is not strongly dependent on initial values; and 4) the model is not strongly dependent on prior distributions. The model fits were similar regardless of the model configuration. All models converged successfully, but models with partial weights on priors had to be started from the converged parameter from runs with full weight on priors. The senior author's preferred model, B1, was chosen to represent the Bering Sea cod population in 2007. For many years, cod was challenging to assess because age data were limited. In this year's assessment, three more years of age data were added to total 11 years of age data. This addition provides for an age data set of reasonable duration to support an age-structured assessment. In addition, catchability is estimated and natural mortality is fixed in this year's assessment. A simplified selectivity function with four (double-normal) rather than eight (double-logistic) parameters was successfully applied and improved model performance. The results for Model B1 estimate the 2007 spawning biomass for the BSAI stock at 307,000 t, up about 10% from last year's estimate for 2006 and up about 25% from last year's $F_{40\%}$ projection for 2007. Abundance is projected to continue to decrease during 2007-2009 because recent (2000-2004) recruitments are below average.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, and that this stock therefore qualifies for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 320,000 t, 0.34 and 0.42, respectively. Pacific cod qualify for management under sub-tier "b" of Tier 3 because projected biomass for 2007 (307,000 t) is about 4% below $B_{40\%}$. Fishing at an instantaneous rate of 0.33 is projected to result in a 2007 catch of 176,000 t, which is the maximum permissible ABC under Amendment 56. The 2007 ABC was set at the maximum permissible value of 176,000 t, 9% below the 2006 ABC of 194,000 t. ABC is projected to continue to decline; the current estimate of the maximum permissible ABC for 2008 is 131,000 t. The recommended OFL was determined from the Tier 3b formula, where fishing at a rate of 0.39 gives a 2007 value of 207,000 t, down 10% from the 2006 OFL of 230,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The new maturity-at-length schedule implies that Pacific cod mature earlier than the previous schedule. The new schedule is based on microscopic examination of the ovaries which detected developing eggs in small cod that the previous macroscopic methods had missed.

GULF OF ALASKA

The stock assessment was updated as follows:

1) catch data for 2006 were incorporated.
2) Size composition data from the 2006 commercial fisheries were incorporated.
3) Age composition data from the GOA bottom trawl survey were incorporated.
4) Parameters governing the length-at-age and weight-at-length relationships were re-estimated based on all available data from the NMFS bottom trawl survey time series.

A trawl survey was not conducted in the GOA in 2006. A single model was presented which was similar in structure to the model preferred last year by the Plan Teams and SSC, with Q fixed at 1.0 and M fixed at 0.37. The author noted that he intended to respond to Plan Team requests to explore alternative model structures and the incorporation of longline survey data, but that analysis was precluded by an outside review of the BSAI cod assessment which occurred during the time allotted for assessment preparation

Incorporating the new age data doubled the amount of age information in the model, and allowed the estimation of the length-at-age relationship to be done externally.

The current biomass in this year's assessment places the GOA Pacific cod stock in Tier 3a. Based on the model, the estimated 2007 female spawning biomass for the GOA stock is 126,903 mt, up about 9% from last year's estimate for 2006 and above the *B40%* value of 103,000 mt. These changes are due to the incorporation of additional age information, combined with different estimates of length at age and weight at length, which in turn reduced overall estimated recruitment variability. Less recruitment variability in turn contributes to less variability in stock size, accounting for the slightly more optimistic picture of the stock this year as opposed to last year. Based on the model, the maximum permissible ABC (Tier 3a) for 2007 is 81,200 mt. An ABC of this magnitude would represent an increase 18%, relative to the 2006 ABC. The assessment notes that the 2001-2003 year classes are almost certainly below average, and that biomass is very likely to decrease in coming years as these cohorts work their way through the age structure. The ABC for 2007 is set at 68,859 mt, equal to the actual ABC for 2006, which corresponds to a fishing mortality rate of 0.38. The 2007 OFL under Tier 3a is estimated to be 97,600 mt (86,000 mt for 2008), corresponding to a fishing mortality rate of 0.57. The ABC was apportioned for 2007 and 2008 according to the average of the biomass distribution in the three most recent surveys.

For further information, contact Dr. Grant Thompson at (541) 737-9318.

3. Shelf Rockfish

b. Stock Assessment

GULF OF ALASKA

Pelagic shelf rockfish - ABL

The pelagic shelf rockfish assemblage consists of four species (dusky, dark, yellowtail, and widow rockfish) that inhabit waters on the continental shelf in the Gulf of Alaska (GOA). Dusky rockfish (*Sebastes variabilis*) is by far the most abundant species in the group, and has been the target of an offshore bottom trawl fishery since the late 1980's. Dark rockfish (*S. ciliatus*) share an inshore reef or kelp environment with black rockfish (*S. melanops*), and the two species are often caught together. In 1998, black rockfish in Alaska were placed under state jurisdiction.

In February 2005, the North Pacific Fishery Management Council (NPFMC) initiated a Groundfish Plan amendment to remove dark rockfish from the GOA pelagic shelf assemblage and transfer management to the State of Alaska. The NPFMC GOA Plan Team and the NPFMC Scientific and Statistical Committee (SSC) had endorsed the recommendation of removing dark rockfish in 2004, but action was delayed until the 2005 GOA trawl survey data were available for analysis. In April 2006, Council staff presented the updated information on dark rockfish distribution in a draft environmental assessment (http://www.fakr.noaa.gov/npfmc/analyses/GOA67_406.pdf) to the SSC and Council. The SSC determined there was insufficient information to determine the depth and distribution of GOA dark rockfish. The Council and SSC recommended another iteration of the analyses which included information on the Bering Sea and Aleutian Islands dark rockfish distribution. An

update on available information was provided to the Council in October 2006 and initial review of the updated draft assessment took place at the 2007 February Council meeting. Final action on this amendment should occur at the 2007 April Council meeting.

Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the GOA biennial trawl surveys. This means that full assessments are done only in years that the trawl survey occurs. For age-structured assessments in non-survey years (such as 2006), we now run only the projection model with updated catch data. This satisfies recommendations in 2006 from the Groundfish Plan Team and accounts for changes in catch from last year's estimates. Assessments in non-survey years for rockfish species without an age-structured assessment or projection model use information from the previous year's stock assessment to determine this year's estimates. As with the 2005 full stock assessment, the average of exploitable biomass from the three most recent trawl surveys was used to determine the recommended ABC for dark, widow, and yellowtail rockfish, while an age-structured model was used for dusky rockfish. For the pelagic shelf rockfish assemblage, ABC and OFL for dusky rockfish are combined with the ABC and OFL for dark, widow, and yellowtail rockfish. For the 2007 GOA fishery, we recommend the maximum allowable ABC for the pelagic shelf rockfish complex of 5,542 mt. This ABC is similar to last year's ABC of 5,436 mt. The stock is not overfished, nor is it approaching overfishing status.

For more information, contact Chris Lunsford at (907) 789-6008 or Kalei Shotwell at (907) 789-6056.

4. Slope Rockfish

a. Research

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Species Identification of Young-of-the-Year Rockfish and Population Genetic Structure of Pacific Ocean Perch Collected in Offshore Waters of the Gulf of Alaska and Bering Sea

Young-of-the-year (YOY) *Sebastes* rockfish were collected as "bycatch" during Auke Bay Laboratory (ABL) Ocean Carrying Capacity surveys of juvenile salmon in the Gulf of Alaska (GOA) in 1998, 2000–2003, and in the Bering Sea in 2002. The YOY rockfish were caught in rope trawls towed near the surface in offshore waters of both regions. Species identification of more than 2,000 specimens using mitochondrial DNA (mtDNA) analysis by ABL scientists in cooperation with Dr. Tony Gharrett of the University of Alaska Fairbanks (UAF) along with identification of a subset of several hundred specimens using morphological analysis by Dr. Arthur Kendall (retired from AFSC's RACE Division) revealed that the majority of the rockfish were Pacific ocean perch (*S. alutus*; POP). Twelve other species were also identified: black, darkblotched, dusky, northern, redstripe, rougheye, sharpchin, shortraker, widow, yelloweye, yellowmouth, and yellowtail rockfish. With funding from the North Pacific Research Board, Dr. Gharrett and graduate student Lisa Kamin are examining the population structure of the POP using a suite of microsatellite DNA markers to determine the extent of genetic divergence between year-classes and between geographic locations. We are planning species identification

of additional collections of YOY rockfish caught in offshore surface waters of northern SE Alaska in August 2006 and in the Bering Sea in September 2006.

A report focusing on species description at this life history stage using morphological features is under review, and a preliminary report on the genetic identifications is in press. We anticipate a third report that will compare the geographic distribution of species in these collections around the Gulf of Alaska within and between years.

For more information, contact Chris Kondzela at (907) 789-6084.

Rockfish Assemblage Analysis

During the fall of 2007 Chris Rooper completed a retrospective analysis of trawl survey data to identify assemblages of rockfish in the Gulf of Alaska and Aleutian Islands. The analysis used non-traditional method for identifying assemblages by first calculating catch-weighted mean depth, temperature and position (and associated variance) for each rockfish species commonly captured in the trawl survey. These distributions across environmental variables were then used to calculate an overlap index between species pairs based on niche theory. Clustering of the overlap index between species pairs resulted in four distinct assemblages of rockfish species found on the continental shelf and slope of Alaska.

The assemblages were sharply divided along gradients of depth and position and, to a lesser extent, along temperature gradients. The major divisions indicate an assemblage inhabiting mid-depths on the upper slope and shelf and a deeper assemblage distributed with a dividing line at approximately 180 m. In addition to the depth division, another noticeable transition was between species centered in southeastern Alaska and those found in the north Gulf of Alaska and the Aleutian Islands. The distribution of species over environmental gradients was correlated to their frequency of co-occurrence in trawl catches, indicating those species with similar environmental preferences were more likely to be captured together.
The method of defining rockfish assemblages by determining the natural distributions of each species group along environmental gradients and examining the potential overlap among species distributions is different than commonly utilized methods that cluster trawl survey catches or stations with similar catch constituents. However, the method used here provided similar results to other studies and, because it is based on an ecological framework, it may be more robust for prediction and management purposes.

For more information, please contact Chris Rooper, (206) 526-4689.

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Rockfish Modeling Workshop

A rockfish modeling workshop was convened on May 23–25, 2006 at the Auke Bay Laboratory (ABL) to advance assessment analyses of rockfish in Alaska. The workshop objectives were to review the modeling history of rockfish, evaluate where improvements are needed, and identify key assumptions and sources of uncertainty in current rockfish assessment

models. The potential for incorporating ecosystem components in rockfish stock assessments was also discussed in addition to approaches for communicating model results for the annual Stock Assessment and Fishery Evaluation (SAFE) reports. Participants included managers and scientists from ABL, REFM, the NMFS Alaska Regional Office, and the Alaska Department of Fish and Game.

Key life history features among rockfish species and stocks were compared. While age-at-maturity data for Pacific ocean perch (POP), *Sebastes alutus*, appears to be adequate for assessment purposes, data on many other rockfish species were lacking. Natural mortality assumptions/estimates for Alaskan rockfish species were generally consistent with growth and longevity patterns. Estimates of bottom-trawl area-swept survey "catchability" varied considerably among species. Simulation analyses presented at the workshop revealed some evidence that patchy populations that tend to cluster by age/size may result in biased catchability estimates. Further analyses and research on the impact of expanding within stratum area-swept estimates over untrawlable regions are needed. Presentations on the impact of estimating recruitment variability terms showed that this was problematic. The workshop recommended that fixed values for this dispersion term be used.

Evaluations on the rockfish models note that they are fundamentally Bayesian in that prior distributions are assumed and, for measures of uncertainty, posterior distributions are traditionally presented. The workshop concluded that the current SAFE reports could be improved by better documentation on how prior distributions were developed. The group also suggested that the shape and distribution of priors be included in the SAFE documents. For posterior distribution analyses, the Markov Chain Monte Carlo (MCMC) integration is typically used. The group discussed using a basic set of chain diagnostics to check for convergence (i.e., that the posterior distribution is adequately represented). The workshop recommended establishing a standardized approach for MCMC presentation and developing a common set of libraries, perhaps available via an intranet site. The group examined different SAFE reports and developed a standard list of tables and graphs. Regarding the ecosystem considerations section of the SAFE report, the workshop noted that developing models to evaluate environmental covariates may be most useful. For improving rockfish stock assessments, it may be more important to include environmental covariates affecting transport/recruitment rather than predation effects, because rockfish mortality does not appear dominated by predation.

A workshop summary and set of recommendations for future rockfish age-structured models was developed. In the short term, participants suggested 1) adding tables in SAFE reports that clearly document management activities; 2) carefully evaluating different data sets for quality; 3) developing a system to evaluate model configurations where hypotheses about model assumptions can be easily performed; 4) evaluating the impact of different data sets on model results; 5) describing prior assumptions clearly and including associated posterior distributions; 6) standardizing computer code among rockfish stocks, particularly for generating standardized output and evaluations; and 7) comparing results between areas and models to understand where assumptions and differences may exist. For the longer term: a) collect more maturity samples for a number of species; b) continue research into larval viability of older rockfish mothers; c) explore the utility of environmental covariates in rockfish models; d) consider time-varying parameters; e) where data exist, investigate more spatially explicit model configurations; and f) evaluate the use of alternative likelihood specifications (e.g., robust forms).

For more information, contact Kalei Shotwell at (907)789-6056 Dana Hanselman at 789-6626.

Rockfish CIE Review

A Center for Independent Experts (CIE) Review Panel convened June 19-22, 2006, at the Alaska Fisheries Science Center in Seattle to consider the current harvest strategies and stock assessment methods for Alaskan rockfish stocks. Three reviewers were contracted: Dr. Patrick Cordue, Dr. Cynthia Jones, and Dr. Robert Mohn. The primary motivation for the review was the concern of some stakeholders that rockfish harvest strategies are "too aggressive" and to validate the current methods being used to assess rockfish. ABL and other AFSC staff presented a wide variety of relevant information and conducted exploratory model runs as requested by the reviewers.

The main conclusions of the reviewers were that there are multiple and cumulative layers of conservatism in the current harvest strategy which will conserve rockfish stocks at high levels of biomass. The current assessments are of high quality and at the appropriate spatial scale, given the limited knowledge about stock structure and migration patterns. Suggestions were to improve basic biological knowledge of maturity, migration and stock structure, develop informative prior distributions for key parameters, and consider more uncertainty in projection modeling. The summary document is available on the AFSC website at http://www.afsc.noaa.gov/refm/docs/2006/RF_CIE.pdf.

For more information contact Dana Hanselman at (907) 789-6626.

Another concern raised by the CIE Review panel had to do with the possible source of bias resulting from expanding bottom trawl survey estimates, particularly those for rockfish, obtained in trawlable portions of the survey area over untrawlable portions of the survey area. In response to this concern, the RACE Groundfish Assessment Program assembled a team to focus on methods to identify and distinguish trawlable from untrawlable grounds in the Gulf of Alaska. They initially reviewed existing information gleaned from past trawl surveys to derive estimates of the proportion of untrawlable bottom in each of the survey strata. This spring they conducted a two-week cruise to collect split-beam echosounder data corrected for vessel attitude and motion to assess whether these sorts of data can be useful in the classification of bottom trawlability.

For more information contact Michael Martin at (206) 526-4175.

BERING SEA AND ALEUTIAN ISLANDS

Pacific ocean perch (POP) - Pacific ocean perch assessments are conducted on a two year cycle to coincide with the Aleutian Islands survey cycles. Since the survey was conducted in 2006, a full stock assessment was performed.

The 2006 assessment updated the previous assessment by including the 2006 Aleutian Islands survey results and the 2004 and 2005 Aleutian Islands fishery age compositions. The Aleutian Islands survey resulted in a biomass estimate of 667,300 t, a 15% increase over 2004 and the highest estimate during the time-series. Stock assessment model results indicate that Pacific ocean perch total and spawning biomass were at low levels in the 1970s and increased to the present high and stable levels.

Changes in assessment methodology include estimation of the natural mortality rate *M*, AI trawl survey catchability in the model using prior distributions and the assumption that

numbers at age prior to the first year of the model are in equilibrium with an unfished population. In previous assessments, the numbers at age prior to the first year of the model were not assumed to be in equilibrium and reflected variation in recruitment strength for each cohort. In addition, model runs were made to evaluate the utility of dropping the CPUE survey index and to evaluate the utility of modeling time-varying fishery selectivity. These changes were investigated in a series of five models (Models 1-5).

The authors selected Model 3 as the preferred model. This model is similar to that used for POP in the GOA – including model estimates of *M* - but also adds estimation of time varying selectivity. The author provided rationale for including time-varying selectivity based on documented changes over time in catch by area and depth, which could contribute to varying selectivity over time. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying Pacific ocean perch for management under Tier 3. The current estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ are 133,000 t, 0.059, and 0.070 respectively. There are reliable estimates of the 2006 spawning biomass (*B*), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ and $B > B_{40\%}$ (155,000 t > 133,000 t). Therefore the POP reference fishing mortality is defined in tier 3a. For this tier, F_{ABC} is constrained to be $\leq F_{40\%}$, and F_{OFL} is constrained to be equal to $F_{35\%}$. The ABC associated with the $F_{40\%}$ level of 0.059 is 21,900 t. This ABC is approximately 7,320 t higher than last year's recommendation of 14,800 t. The change in ABC reflects the increase in $F_{40\%}$ from the 2005 update, which was caused by an estimated M (0.06) higher than the fixed level (0.05) used in previous assessments. The recommended ABC (21,900 t) is a marked increase over last year's ABC. However this increase is consistent with increases in trawl survey biomass. The increases in model- and survey-estimated biomasses suggest a successful re-building trajectory for this population. For the Aleutian Islands, the ABCs are set for each region based on the proportions in combined survey biomass as follows: BS = 4,160 t, Eastern Aleutians (Area 541) = 4,970 t, Central Aleutians (Area 542) = 5,050 t, Western Aleutians (Area 543) = 7,720 t. The OFL fishing mortality rate is computed under Tier 3a as 26,100 t, which is the recommended OFL for the BSAI. The OFL for BSAI is not regionally apportioned. For 2007, the recommended ABC is 21,900 t, and the OFL is 26,100 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Northern rockfish - Northern rockfish assessments are conducted on a two year cycle to coincide with the Aleutian Islands survey cycles. Since a survey was conducted in 2006, a full stock assessment was performed to determine the 2007 harvest level.

The 2006 Aleutain Islands survey biomass estimate was 218,000 t, a 14% increase over 2004 and the highest point estimate from the survey time series dating back to 1980. The methodology in this year's assessment was the same as in 2004, with updated catch data, survey data, and an addition of substantially more aging data. Despite this, uncertainty about selectivity led to the authors' recommendation to use a model with constrained selectivity (Model 2 in the assessment). The SSC has determined that this stock qualifies for management under Tier 3 due to the availability of reliable estimates for $B_{40\%}$ (52,000 t), $F_{40\%}$ (0.045), and $F_{35\%}$ (0.053). Because the female spawning biomass of 72,800 t is greater than $B_{40\%}$, sub-tier "a" would be applicable, with $F_{ABC} = F_{40\%}$ and $F_{OFL} = F_{35\%}$. Under Tier 3a, the maximum permissible ABC is 8,190 t, which is the 2007 ABC. Under Tier 3a, the 2007 OFL is 9,750 t for the Bering Sea/Aleutian Islands combined. The TAC of the previous year was assumed as the 2007 catch, in order to make projections to 2008. Model projections indicate that this stock is neither overfished nor approaching an overfished condition. The stock assessment model indicates that

the northern rockfish stock steadily increased from 129,000 t in 1977 to 211,000 t in 1999, and has remained at that high and stable level the past 7 years.

Shortraker/rougheye rockfish - Since there was an Aleutian Islands survey in 2006, a full update of the stock assessment was performed this year. The 2006 Aleutian Islands survey biomass estimates for shortraker and rougheye rockfish were 12,961 t and 9,505 t, respectively. These estimates are of the same magnitude of other surveys conducted in the Aleutian Islands since 1991. The stock assessment model indicates that the rougheye rockfish resource has slowly declined to less than half of the biomass estimated for 1980, the initial year in the model. Shortraker rockfish are estimated to have been fairly stable over the same period, declining 13% from the 1980 abundance level.

The assessment methodology used is a straightforward update of last year's assessment, adding new catch data and biomass estimates from the 2006 Aleutian Islands survey. The SSC has previously determined that reliable estimates of biomass and natural mortality exist for shortraker and rougheye rockfish, qualifying the species for management under Tier 5. F_{ABC} was set at the maximum permissible level under Tier 5, which is 75% of M. Accepted values for M for these stocks, 0.025 for rougheye rockfish and 0.030 for shortraker rockfish, resulting in F_{ABC} values of 0.019 and 0.023 for rougheye and shortraker, respectively.

In 2001, the Plan Team, SSC, AP, and Council recommended separating shortraker and rougheye rockfish species and setting BSAI area-wide ABCs and TACs for 2002. However, NMFS was unable to implement those recommendations because of the difficulty of species identification, and instead set separate BS and AI TACs for the combined shortraker/rougheye rockfishes category. In 2004, the NMFS Regional Office and Observer Program developed a catch accounting program that separated shortraker and rougheye rockfishes. With this improvement, concerns over management of small OFLs led to recombining regions into a BSAI-wide quota for each species. The author presented comparisons of length compositions, age compositions, and size compositions for the two species between regions, showing several significant differences between regions for rougheye and fewer for shortraker. In previous years, the author has recommended an area split; this year, this recommendation was deferred pending a new model for next year, although he noted several biological factors which might justify such a split.

The biomass estimates for 2007 are 18,900 t for shortraker rockfish and 10,800 t for rougheye rockfish, leading to BSAI OFLs of 564 t for shortraker and 269 t for rougheye, and ABCs of 424 t for shortraker and 202 t for rougheye. It is not possible to determine whether these species are overfished or whether they are approaching an overfished condition because they are managed under Tier 5.

Other rockfish complex - The BSAI "Other Rockfish" are also managed on a two year cycle to coincide with years when an Aleutian Islands survey is conducted. This complex formerly consisted of 28 *Sebastes* and *Sebastolobus* species, but now considers only the 8 species that have been caught at least once during AFSC research surveys or appeared in more than 1% of observed fishery hauls between 1990 and 2001. The assessment is updated for 2006 and includes the 2006 Aleutian Islands and Bering Sea survey biomass, catches in the EBS and AI, updated length frequency data. The authors recommend assigning a separate ABC and OFL to shortspine thornyheads and leaving the remaining 7 rockfish species within the other rockfish complex. This recommendation was based on the fact that shortshine thornyheads are the most

abundant and valuable species in the complex and inhabit deeper regions of the shelf and slope than the others.

For 2007, the authors recommend an M=0.03 for SST and an M=0.09 (based on dusky rockfish) for the remaining species. Multiplying these rates by 0.75 and the best estimates of SST and other "other rockfish" biomass yields 2007 and 2008 ABCs of 414 t in the EBS and 585 t in the AI. The OFL was set for the entire BSAI area, which under Tier 5 is calculated by multiplying the best estimates of total biomass for the area by the separate Ms and adding the results, which yields an OFL of 1,330 t

For further information, contact Paul Spencer at (206) 526-4248.

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Pacific ocean perch - Pacific ocean perch (POP), *Sebastes alutus*, is the dominant fish in the slope rockfish assemblage and has been extensively fished along its North American range since 1940. Since 2005, Gulf of Alaska rockfish have been moved to a biennial stock assessment schedule to coincide with the biennial trawl survey. In even years (such as 2006's assessment for the 2007 fishery) when the survey does not occur and the only new data are catch information, we run only the projection model with updated catch data for single-species age-structured assessments. This satisfies recommendations from the 2006 Groundfish Plan Team and accounts for changes in catch from last year's estimates. New information for this year's projection model was updated 2005 catch at 11,272 mt and the best estimate of the 2006 catch at 13,654 mt. Last year's estimates were 11,356 mt and 11,930 mt for 2005 and 2006, respectively. Substantially more POP were caught in 2006 than expected due to good market conditions. For the 2007 fishery, we recommend the maximum allowable ABC of 14,636 mt from the updated projection. This ABC is similar to last year's ABC of 14,261 mt, but slightly less than last year's projection due to the increased catch in 2006. Female spawning biomass remains above $B_{40\%}$, with projected biomass stable.

For more information contact Dana Hanselman at (907) 789-6626.

Northern rockfish - For northern rockfish, a new model was accepted in 2006 for recommending 2007 ABC. This configuration is very similar to the models used for the Gulf of Alaska (GOA) Pacific ocean perch, dusky rockfish, and rougheye rockfish assessments. This model was reviewed at a rockfish modeling workshop held in Juneau in the spring of 2006 and at a subsequent Center for Independent Experts (CIE) panel. It differs from the other GOA models by using a logistic selectivity curve, rather than smoothed penalty function. The model differs from the previous northern rockfish assessment to conform to other GOA rockfish models by estimating separate selectivities for the survey and fishery, estimating average recruitment with annual deviations instead of a stock-recruitment relationship, and by adding the option to estimate natural mortality with an informed prior distribution. Overall the new model exhibited better fits to the data, and more plausible estimates of key parameters. For the 2007 fishery, we recommended the maximum allowable ABC of 4,940 mt for the Gulf of Alaska. This ABC is down slightly from last year's recommended ABC of 5,090 mt. This stock is not overfished nor approaching an overfished condition; however, projected biomass indicates some decline in the future.

For more information, contact Dana Hanselman at (907) 789-6626.

Rougheye rockfish - In Alaskan waters, adult rougheye rockfish (*Sebastes aleutianus*) inhabit particularly steep, rocky areas in a narrow band along the upper continental slope at depths of 300–500 m. The fish are relatively evenly distributed within this habitat and often co-occur with shortraker rockfish (*Sebastes borealis*) in trawl or longline hauls. Rougheye rockfish have been managed as "bycatch" only species since the creation of the shortraker/rougheye rockfish management subgroup in the Gulf of Alaska (GOA) in 1991. Recent studies on the genetic differences between the observed types of rougheye rockfish indicate two distinct species. The southern species of rougheye rockfish now proposed as *S. aleutianus* or rougheye rockfish is typically lighter in coloration with spots absent from the spinous dorsal fin and possibly has mottling on the body. The northern species of rougheye rockfish now proposed as *S. melanostictus* or blackspotted rockfish is often darker in body coloration with distinct spots present on the dorsal fin and body. The two species occur in sympatric distribution with rougheye extending farther south along the Pacific Rim and blackspotted extending into the western Aleutian Islands. The overlap is quite extensive; however a potential difference in depth distribution may occur.

In 2005 and 2006, the NMFS sablefish longline survey conducted two-day sampling experiments in the eastern GOA near Yakutat Bay to collect detailed depth information associated with the longline catch of rougheye and blackspotted rockfish. New GPS and sonar technology on board combined with numerous time-depth recorders along the groundline were used to determine accurate depth and GPS coordinates of the groundline as it was fished. Approximately 250 rougheye and blackspotted rockfish were collected across a depth range of 200-400 m with associated photos of 150 fish and observer identification based on the features in a pamphlet distributed by J. Orr of the AFSC RACE Division. Genetic analysis of these samples is in progress. Preliminary discussions with researchers from this experiment suggest that identification of each species was difficult due to the range of coloration and spotting between individuals.

At present there appears to be difficulty in accurate field identification between the two species. Methods should be developed and tested that would enable rapid and accurate field identification of the two species by observers and scientists so that population estimates and catch accounting can occur. In addition, studies should be undertaken that assess whether the two species have significantly different life history traits (i.e. age of maturity and growth). Until such information and studies occur it will be difficult to undertake distinct population assessments. Ongoing research in this area may determine particular habitat preference that might be useful for separating the species, and phenotypic research may determine a distinct combination of characters for onboard identification.

In 2005 we formalized the use of the generic rockfish model as the primary assessment tool for rougheye rockfish (*Sebastes aleutianus*). Additionally in 2005, Gulf of Alaska rockfish were moved to a biennial stock assessment schedule to coincide with the biennial trawl survey. In even years (such as 2006's assessment for the 2007 fishery) when there is only new catch information, we run only the projection model with updated catch data for single-species age-structured assessments. New information for this year's projection is updated 2005 catch at 301 mt and the best estimate of the 2006 catch at 327 mt. Last year's estimates were 289 mt and 288 mt for 2005 and 2006, respectively. For the 2007 fishery, we recommend a maximum allowable ABC of 988 mt from the updated projection. This ABC is similar to last year's ABC of 983 mt. Female spawning biomass remains above $B_{40\%,}$ with projected biomass stable. Several more

years of age samples were completed for rougheye by the AFSC REFM Division's Age and Growth Task and will be incorporated into next year's assessment model. As per the North Pacific Fishery Management Council's Science and Statistic Committee comments in December 2005, we plan to incorporate a sensitivity analysis of the weighting between the longline and trawl survey data and to consider the relative influence of the length and age compositions from both surveys on model fit.

For more information, contact Kalei Shotwell at (907) 789-6056.

Shortraker and other slope rockfish - Shortraker rockfish and "other slope rockfish" are distinct management categories in the Gulf of Alaska (GOA), but their assessments are presented in a combined report because both assessments are based on biomass estimates from trawl surveys, instead of modeling. "Other slope rockfish" are comprised primarily of sharpchin, harlequin, silvergray, and redstripe rockfish, plus a number of minor species. Rockfish in the GOA have been moved to a biennial stock assessment schedule to coincide with data from the GOA biennial trawl surveys. This means that full assessments are done only in years that the trawl survey occurs. Because 2006 was not a survey year, no assessment was done, and ABCs for the 2007 fishing year remained unchanged from those in 2006. Exploitable biomass for shortraker rockfish and "other slope rockfish" was estimated by the average biomass in the three most recent biennial trawl surveys (2001, 2003, and 2005), excluding the estimated biomass in the 1-100 m stratum. The 1-100 m depth stratum was removed from the estimate because most rockfish in this stratum are small juvenile fish, and thus are not considered exploitable. This results in an exploitable biomass of 37,461 mt for shortraker rockfish and 93,552 mt for "other slope rockfish". Applying either an F=0.75M or an $F=F_{40\%}$ rate (depending on the species) to these values of exploitable biomass results in recommended ABCs for the Gulf of Alaska in 2007 of 843 mt for shortraker rockfish and 4,154 mt for "other slope rockfish".

Shortraker rockfish have long been considered one of the most difficult rockfish species to age. In 2005, the AFSC REFM Division's Age and Growth Task developed a new, experimental technique for ageing otoliths of this species. In early 2007, this technique was used for the first time for "production ageing" of a sample of shortraker rockfish from one of the GOA trawl surveys. Although the results are still preliminary, the average age of the samples was quite old (~44 years), and the maximum age was 116 years. If additional samples can be successfully aged, development of an age-structured model for shortraker rockfish may begin in the next couple of years.

For more information contact Dave Clausen at (907) 789-6049.

6. Thornyheads

b. Stock Assessment

c.

GULF OF ALASKA

As no new survey was conducted in the GOA in 2006, the 2005 assessment recommendations were used for the 2007 fishing season. The highlights of the 2005 assessment are presented below.

Although an age structured model has been developed for the thornyheads, the lack of age composition data from GOA trawl surveys, sablefish longline surveys, and improved length sampling from longline and trawl fisheries has prevented its use for determining ABC and TAC for these species. Thornyhead rockfish are commercially valuable species which are presently not targeted in a directed fishery but are caught incidentally as bycatch in directed fisheries for rockfish, flatfish and sablefish. The catch in recent years is well below the TAC and has been declining. The exploitable biomass for determining the harvest level is calculated as the average of the biomass estimates from the 2003 and 2005 trawl surveys, which is 98,158 t.

The ABC was determined using Tier 5 methodology by multiplying the exploitable biomass by M=0.03 and 0.75 giving 2,209 mt**.** The corresponding OFL recommendation results in 2,945 mt. The OFL fishing mortality rate under Tier 5 is set equal to the estimate of *M*, so F_{OFL}=0.03. Area apportionments for thornyhead ABC's in 2006 and 2007 are as follows.

Western	Central	Eastern	Total
513	989	707	2,209

For further information contact Dr. James Ianelli (206) 526-6510.

6. Sablefish

a. Research

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

2006 Sablefish Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987-2006. The survey is a joint effort involving two divisions of the AFSC: ABL and RACE. It replicates as closely as practical the Japan-U.S. cooperative longline survey conducted from 1978-94 and also samples gullies not sampled during the cooperative longline survey. In 2006, the twenty-eighth annual longline survey of the upper continental slope of the Gulf of Alaska was conducted, along with a similar survey of the eastern Aleutian Islands. One hundred-forty-eight longline hauls (sets) were completed between June 4, 2006 and September 1, 2006 by the chartered fishing vessel *Alaskan Leader*. Sixteen kilometers of groundline were set each day, containing 7,200 hooks baited with squid.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), shortspine thornyhead (*Sebastolobus alascanus*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*). A total of 87,032 sablefish were caught during the survey compared to 81,460 in 2005. A total of 3,930 sablefish, 645 shortspine thornyhead, and 39 Greenland turbot (*Reinhardtius hippoglossoides*) were tagged and released during the survey. Electronic temperature-depth tags were surgically implanted in 35 Greenland turbot. Over 121,000 lengths were collected from six different species, and otoliths and specimen data were collected from 2,320 sablefish. Killer whales (*Orcinus orca*) took fish from the longline at five stations in the Aleutian Islands and western Gulf of Alaska near Dutch Harbor. Sperm whales *(Physeter macrocephalus*) were common near the vessel in the

eastern Gulf, west Yakutat, and central Gulf regions and were observed taking fish from the line at eight stations.

Several special projects were conducted during the 2006 longline survey. Corals caught on the line were collected for identification and sample preservation. A seabird occurrence study was conducted for the fifth year, which helps to address where and when certain seabird species occur in Alaska waters. Spiny dogfish were sampled during the west Yakutat and central Gulf legs for biological studies conducted by graduate students from the University of Alaska Fairbanks and the University of Washington. A giant grenadier reproductive biology study was conducted during the Southeast leg, and maturity samples of these fish were taken for histological analysis.

A marine mammal observer was on board during the first two survey legs in the Aleutian Islands and the western Gulf of Alaska to collect photo identification of resident killer whales that were observed depredating on the gear. A second marine mammal observer studied sperm whale depredation in the eastern and central Gulf of Alaska. Photo identification, dive behavior observations, and biopsy samples were collected. Finally, a 2-day experiment was conducted off Yakutat to collect genetic tissues of rougheye rockfish and to investigate depth distribution patterns of the "light" and "dark" color phases of these fish that are now believed to be separate species.

For more information, contact Chris Lunsford at (907) 789-6008.

Auke Bay Laboratory Sablefish Tag Recovery Program

Processing tag recoveries and administration of the reward program continued during 2006. Total sablefish tags recovered for the year so far are 598, which includes 574 tagged as adults and 24 tagged as juveniles. Two sablefish at liberty for 33 years were recovered in 2006. Both were released and recovered in Chatham Strait. A third fish, out for 28 years, was tagged near Prince William Sound in 1978 and recovered in 2006 in the eastern Shumagins.

Recoveries of other species maintained in the Sablefish Tag Database included 11 shortspine thornyheads, 2 Greenland turbot with archival tags, and 1 spiny dogfish with an archival tag. The dogfish, a female, traveled 821 miles from the Yakutat area to southern Vancouver Island in the 325 days it was at liberty. It was actually caught in 2005, but the fisherman kept it in his freezer for a year before returning it 2006.

Total fish tagged and released in 2006 were 4,698, including 3,930 adult sablefish, 645 shortspine thornyheads, and 39 Greenland turbot on the sablefish longline survey, and 84 juvenile sablefish in southeast Alaska.

The Tag Database was the only Oracle database at the Auke Bay Laboratory, and it was becoming increasingly expensive and inefficient to maintain the Oracle platform. To solve this problem, the database was converted from Oracle to Access during 2006.

For more information, contact Nancy Maloney at (907) 789-6060.

Juvenile Sablefish Studies

Juvenile sablefish studies have been conducted by the Auke Bay Laboratory in Alaska since 1984 and were continued in 2006. A total of 18 juvenile sablefish (age 1+) were tagged with spaghetti tags and released during a cruise of the NOAA vessel *John N. Cobb* at St. John Baptist Bay near Sitka between May 14-20 2006. During the same cruise, an additional 66 juvenile sablefish were implanted with electronic archival tags. Approximately 174 rod hours were recorded. This relatively small bay is the only known location in Alaska where juvenile sablefish have been consistently found on an annual basis.

The electronic archival tags will provide information on juvenile sablefish behavior and habitat during their transition from nearshore rearing areas to the age at which they are intercepted by the fishery. Since 2003, a total of 389 electronic archival tags have been released on juvenile sablefish in St. John Baptist Bay. These tags record the temperature and depth experienced by the fish and are designed for recovery in the commercial fishery when the fish are age 2+ or greater.

For more information, contact Thomas Rutecki at (907) 789-6051.

Sablefish Migration

A paper by Heifetz and Fujioka (1991) used a Markovian movement model to estimate migration between large management areas and into British Columbia (B.C), Canada. Their general conclusion based on model estimates was to support previously reported information that small fish move west and then return as they get larger to spawning locations in the eastern Gulf of Alaska.

Recently, this model was recoded into AD Model Builder, which will be more amenable to the geometric growth of data, be easier to test more complex stock hypotheses, and more accurately account for uncertainty. Preliminary results from this model using updated tag recovery data through 2005 show conclusions similar to Heifetz and Fujioka's study, but lend less support for a strong westerly movement of small fish (e.g. they are just as likely to move east or west). The model is capable of estimating movement rates to B.C., but does not have the required data to estimate rates from B.C. to Alaska.

Future plans are to attempt new movement hypotheses, with more dimensionality, and include smaller scale directional movement (e.g. inshore versus offshore or radial directionality). Eventually, this information may become important in Alaska for spatially-explicit stock assessment and apportionment of quotas.

For more information, contact Dana Hanselman at (907) 789-6626.

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Relative to the 2005 assessment, substantive changes were made in 2006 to the sablefish assessment. The model has been reconfigured as a split-sex model. This was done to account

for the differences in growth and maturity of male and female sablefish. The model now estimates spawning biomass as female-only, which is consistent with other Alaskan assessments. Additionally, the model now incorporates Gulf of Alaska trawl survey lengths and biomass estimates for depths 500 meters and less. This appeared to yield more precise estimates of recruitment, due to the trawl survey's ability to catch younger fish than those caught in the longline survey.

The 2006 sablefish assessment showed that sablefish abundance in Alaska increased during the mid-1960's due to strong year classes from the 1960's. Catches peaked at 53,080 mt in 1972, and abundance subsequently dropped during the 1970's due to heavy fishing. The population recovered due to exceptional year classes from the late 1970's; spawning abundance peaked again in 1987. The population then decreased again as these exceptional year classes died off. The sablefish longline survey abundance index increased 8% from 2005 to 2006 and follows a 2.5% decrease from 2004 to 2005. Relative abundance in 2006 is 16% higher than the recent low in 2000. The fishery abundance index decreased 4% from 2004 to 2005 (the 2006 data are not available yet). Spawning biomass is projected to remain stable from 2006 to 2007. Projected 2007 spawning biomass is 38% of unfished biomass. Abundance has increased from a low of 33% of unfished biomass during 1999 to 2000. The 1997 year class is an important part of the total biomass and is projected to account for 13% of 2007 spawning biomass. The 2000 year class likely is above average and should also account for 13% of spawning biomass in 2007.

We recommend a 2007 ABC of 20,100 mt for sablefish in federally managed waters of Alaska, based on an adjusted $F_{40\%}$ strategy. This ABC is slightly lower than the 2005 and 2006 ABCs which were 21,000 mt. Changes in area apportionment for this year are much more modest compared to the large changes seen in last year's assessment. The largest relative change this year occurred in the West Yakutat area due to sizeable increases in both the survey CPUE in 2006 and the fishery CPUE in 2005. The current apportionment is characteristic of most prior years except for 2004. Future work will concentrate on updating biological parameters, including growth and maturity, and considering environmental variables as proxies for recruitment.

For more information, contact Dana Hanselman at (907) 789-6626.

7. Flatfish

a. Research

Habitat Studies

A five year field survey for juvenile flatfishes conducted with a towed camera sled in nursery grounds of Kodiak was completed in 2006. This survey was designed to provide a spatially-explicit analysis of distribution and habitat association at several spatial scales, from 10's of kilometers to <1 meter, considering a wide range of environmental variables explore (depth, sediments, biogenic structure, etc). The video records are currently under analysis; however, the first statistical evaluations reveal that broad scale distribution is mediated by physical variables such as temperature and depth, while finer-scale local distribution is mediated by biological variables including the presence of emergent structures and biogenic variables such as worm tubes.

Manipulative laboratory and field experiments, conducted in parallel with the field surveys, were designed to examine the potential influence of predator abundance upon habitat value. While predators may remove juvenile fish directly, through predation, their activity may also indirectly influence juvenile flatfish activity, habitat preference and growth. Results of these experiments indicate that age-0 rock sole respond to perceived predation risk over a range of temporal scales. Upon detection of predators, rock sole reduce activity and bury in the sediment. If predation risk is persistent (hours to days), they move to areas of lower perceived risk. Finally, if they are unable to move to habitats of lower risk, growth is inhibited.

Feeding and growth

Examination of the spatial and temporal variation in growth rates of northern rock sole continued in 2006 with monthly sampling at three Kodiak Island nursery sites. Variation in growth rates among sites was similar to 2004, but less than observed in 2005. The rank order of growth rates across sites has been maintained across the three years of study. This work is being extended to examine the potential differences in energetic condition of rock sole among the nursery sites. Preliminary analyses of condition factors indicates that fish at the site with the fastest growth rates also have the highest energy reserves. This suggests even greater differences in recruitment potential among sites than indicated from growth rates alone.

Examination of stomach contents collected during 48 hours of juvenile flatfish sampling in 2004 was completed. The data demonstrated that diets and diel feeding patterns differed among three abundant flatfish species that co-occur in Kodiak Island nursery sites. Northern rock sole, the most abundant flatfish, fed upon benthic infauna such as clam siphons and polychaetes with feeding occurring most rapidly at dusk. English sole also ate benthic infauna, but fed throughout the day. Pacific halibut had peak feeding in the afternoon prior to dusk and fed on the most mobile prey primarily mysids. Differences in diel feeding pattern may be linked to species-specific variation in predation vulnerability associated with their cryptic behavior and depth preferences.

Fishing gear performance

Trawl ground-gear can damage the seafloor by dislodging and/or removing macro-invertebrates that provide habitat for demersal groundfish. The RACE division is developing experimental trawl sweeps that ride several inches above the sediment surface, thus reducing damage to seafloor macro-invertebrates, while minimizing loss of catch. Concurrently, laboratory experiments are being conducted in a 12 m flume in the Newport facility, to examine how distance above the sediment influences the ability of a sweep to initiate herding behavior in flatfish (Pacific halibut, northern rock sole, English sole). Importantly, prior research has demonstrated that flatfish are less likely to initiate herding in the dark. Since ambient light conditions on the seafloor can vary dramatically with depth and turbidity, as well as time of day, experiments are being conducted under both light and dark conditions, to more realistically quantify how various sweep configurations can be expected to perform under realistic fishing conditions.

For further information, contact Dr. Allan Stoner, (541) 867-0165.

b. Stock assessments

BERING SEA

Yellowfin sole - The 2006 stock assessment incorporates the 2006 catch and survey biomass as well as the age compositions from the 2005 survey and 2005 catch. The 2006 EBS bottom trawl survey resulted in a biomass estimate of 2,113,000 t, a decrease of 25% from the 2005 point estimate. The stock assessment model indicates that the stock has been slowly declining over the past twenty years, although still at a high level, due to recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 1970s. The time-series of survey age compositions indicate that only 3 of the past 11 year classes have been above the long term average. The 2006 catch of 96,930 t represents the largest flatfish fishery in the United States and the average exploitation rate has been 4% the past five years for this stock. This assessment features an estimate of the relationship between survey catchability and annual mean bottom water temperature and also estimates a Ricker form of the spawner recruit relationship within the model. Results indicate that catchability, averaged over 24 years, = 1.13.

Several models were analyzed for this assessment, the models differed by changing whether natural mortality (*M*) or catchability (*Q*) were estimated in the model at varying errors on the priors for these parameters. The assessment authors once again considered moving the assessment to Tier 1. The robustness of the Ricker spawner-recruit model was tested by estimating a single spawner-recruit model then using Tier 1 management on simulated stock production from multiple productivity regimes. The productivity regimes were based on observed productivity in the Bering Sea. Though the results indicated that the Tier 1 assessment was robust, the authors still felt that a move to Tier 1 may not be appropriate due to the non-stationarity of the stock-recruitment relationships for Bering Sea yellowfin sole. The Plan Team agreed with the authors and felt that the recovery from low abundance had only occurred once, during a fairly short time period and the spawner-recruit estimate from the most recent regime predicted a B_{MSY} lower than any spawning biomass during the time period.

For these reasons the Plan Team decided to use Tier 3. Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying yellowfin sole for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 460,000 t, 0.11, and 0.13, respectively. Given that the projected 2007 spawning biomass of 585,000 t exceeds $B_{40\%}$, the Plan Team's ABC and OFL recommendations for 2007 were calculated under sub-tier "a" of Tier 3. The Plan Team recommends setting F_{ABC} at the $F_{40\%}$ (0.11) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2007 ABC of 136,000 t. The Plan Team's OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.13 gives a 2007 OFL of 160,000 t.

The SSC, however, determined that reliable estimates of the spawner-recruit relationship do exist for this stock and placed yellowfin sole in the Tier 1 management classification. Therefore, the 2007 ABC for this stock is 225,000 t and the OFL is 240,000 t.

Model projections indicate that this stock is neither overfished nor approaching an overfished condition. This stock is predicted to be fairly stable or decrease slightly in the near future due to below average recruitment in the last 5 years.

Northern rock sole - Changes to the input data for the 2006 assessment include addition of the 2005 fishery age composition, 2005 survey age composition, the 2006 catch biomass and

2006 trawl survey biomass point estimate and standard error. The 2006 bottom trawl survey resulted in a biomass estimate of 2,215,000 t, a 4.5% increase over last year's estimate of 2,119,000 t. The assessment continued the investigation of catchability (q) began in 2002. As in past assessments, a value of 1.4 obtained from a trawl "herding" experiment was used as the mean of a prior distribution on q. The updated value from this assessment gives a q estimate of 1.53. Natural mortality was estimated as a free parameter (with q constrained as stated above) giving the best fit at M = 0.155. The model estimates that the biomass of rock sole has increased the past three years after declining from a peak value observed in 1995. The increase is due to strong recruitment from the 2001 and 2002 year classes which are now entering the observable portion of the population. The model estimates the 2007 biomass of rock sole at 1,582,000 t, an increase of 5% over 2005 and about 13% less than the peak level observed in 1995.

The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 222,000 t, 0.14, and 0.17, respectively. Given that the projected 2007 spawning biomass of 392,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2007 could be calculated under sub-tier "a" of Tier 3. The Plan Team recommended setting F_{ABC} at the $F_{40\%}$ (=0.14) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2007 ABC of 121,000 t. OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.17 gives a 2007 OFL of 144,000 t.

The SSC, however, determined that reliable estimates of the spawner-recruit relationship do exist for this stock and placed northern rock sole in the Tier 1 management classification. Therefore, the 2007 ABC for this stock is 198,000 t and the OFL is 200,000 t.

Flathead sole - The latest assessment updated the previous by incorporating new catch, discard, survey biomass, length composition, and age composition data. The 2006 trawl survey biomass estimate of 645,000 t was about 4% increase over last year's estimate of 629,000 t. Survey biomass has been relatively stable over the past four years compared to the decrease observed from 1998-2000.

The author undertook an examination of the lumping of youngest and oldest age classes in previous assessments, disaggregating these age classes in the current assessment may have led in part to the 35% increase in assessed biomass over last year; the Plan Team felt that this new model was an improvement and recommended its use.

In response to SSC comments, the author examined the distribution of Bering flounder with respect to the fishery. The northerly distribution of the species did not seem to overlap the spatial distribution of the fishery, although mismatch in seasonal timing of the survey versus the fishery means that this is not conclusive. The SSC has determined that reliable estimates of $B_{40\%}$ (145,000 t) $F_{40\%}$, (0.31) and $F_{35\%}$ (0.37) exist for this stock, thereby qualifying the stock for management under Tier 3. Given that the projected 2007 spawning biomass of 274,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2007 were calculated under sub-tier "a" of Tier 3. F_{ABC} was set at the $F_{40\%}$ (0.31) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2007 ABC of 79,200 t. The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.37 gives a 2007 OFL of 95,300 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Alaska plaice - The 2006 assessment incorporated the 2006 shelf survey biomass estimate (636,971 t) and the 2006 catch data into the stock assessment model as well as the 2005 survey age composition. The survey biomass estimate was 26% higher in 2006 than in 2005. The stock is estimated to be at a high and stable level with relatively stable recruitment since the

1970s and a low level of harvest which is typically bycatch from other target fisheries. Catchability investigations do not indicate a temperature effect as shown for some of the other shelf flatfish.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore qualifying it for management under Tier 3a of the BSAI Groundfish FMP. The updated point estimates are $B_{40\%}$ = 138,000 t, $F_{40\%}$ = 0.61, $F_{35\%}$ = 0.83. These are high values for flatfishes, but these values are the consequence of Alaska plaice maturing before recruiting to the fishery. Given that the projected 2007 spawning biomass of 295,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2007 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the $F_{40\%}$ level gives a 2007 ABC of 190,000 t. The OFL was determined from the Tier 3a formula, which gives a 2007 OFL of 241,000 t. Model projections indicate that this species is neither overfished nor approaching an overfished condition. Reference fishing mortality rates are lower than in previous years due to a shift in the model's estimate of fishery selectivity. The sensitivity of the spawning-per-recruit fishing reference point to the change in fishing selectivity is not unexpected, given that the age at 50% maturity is approximately 8.5 and the natural mortality rate (0.25) is relatively high compared to other flatfishes. Because the age at 50% selection in the fishery is 10.4, Alaska plaice has the potential to spawn twice before it recruits to the fishery. Additionally, the high natural mortality of 0.25 indicates that the lifetime spawning/recruit potential is rapidly reducing at the ages of highest fishing selectivity. There continues to be relatively stable recruitment of Alaska plaice from the late 1970s through the present, with an apparently large 2002 year class.

Other flatfish - The "other flatfish" complex currently consists of Dover sole, rex sole, longhead dab, Sakhalin sole, starry flounder, and butter sole in the EBS and Dover sole, rex sole, starry flounder, butter sole, and English sole in the AI. Starry flounder, rex sole, and butter sole comprise the vast majority of the species landed. For example, Starry flounder and rex sole comprised 90% of the "other flatfish" catch in 2005. Because of insufficient information about these species, no model analyses are possible. The latest assessment incorporates 2006 total catch and discard and 2006 trawl survey information. The 2006 EBS bottom trawl survey resulted in biomass estimates of 132,900 t, an increase from the estimate of 107,500 t from the 2005 survey and the highest observed since 1980. The biomass of these species in the Aleutian Islands is 16,400 t from the 2006 survey, the highest observed since 1983.

With the removal of Alaska plaice from this category in 2002 the SSC reclassified "other flatfish" as a Tier 5 species complex with an assumed natural mortality rate of 0.20. Projected harvesting at the 0.75 M level (F_{ABC} =0.15), gives a 2007 ABC of 21,400 t for the "other flatfish" species. The corresponding 2007 OFL (=0.20) is 28,500 t. It is not possible to determine whether the "other flatfish" complex is overfished or approaching an overfished condition because it is Tier 5 and not managed under Tiers 1-3. Insufficient information about these species makes model analysis impossible.

The SSC requested an evaluation of species-specific natural mortality rates for the species in this complex. Therefore species-specific natural mortality rates are used for the species for which they are available. Estimates of M for the GOA were used for Dover sole (a minor component of the complex) and rex sole (a major component of the complex). Starry flounder natural mortality estimates were examined, but not used as they are only available for San Francisco Bay for data collected in the 1950s. There is no indication that these estimates are valid for starry flounder in the Bering Sea at this time. Proportionally more butter sole are caught in the fishery than in the trawl survey. In response to the SSC's concern about this high

exploitation rate, the authors note that this species is at the northern extent of its range, is at times captured in large quantities in a few trawl hauls, and thus the CV's are quite large. Therefore this is probably not an issue of concern.

Greenland turbot - The Bering Sea slope survey gives the primary estimate of Greenland turbot biomass, but was not conducted in 2006 due to funding deficiencies. This year's Greenland turbot assessment model included updated 2003-2006 catch data, recompiled fishery catch-at-length data by gear type for all post-1988 domestic fisheries, and biomass and length composition estimates from the 2006 The EBS shelf survey. Also included were new age data from 1994 and 1998 surveys, from recent research on age and growth of Greenland turbot, and an updated, aggregated longline survey data index for the EBS and Aleutian Islands.

The 2006 EBS shelf trawl survey biomass estimate was down by about 2% from the 2005 estimate. This compares with the average decline over the past 5 years of 3%. The 2006 Aleutian Islands bottom trawl survey estimate was 20,900 t, an increase of 85% from the 2004 survey estimate and is above the 1991-2006 average level of 17,100 t. Model results based on these surveys and data from longline and trawl fisheries result in an estimate of $B_{40\%}$ equal to 41,800 t (female spawning biomass). The current estimate of the year 2007 female spawning biomass is 60,430 t. While improvements to the assessment modeling have been made, and there appears to be some favorable recruitment patterns in the past several years, fishing mortalities consistent with recent history are recommended for ABCs until another survey can be completed as well as more analyses to evaluate the modeling approach.

The newer implementation of Stock Synthesis 2 was used for modeling. The current implementation of the model retains the key assumption of former models that the slope trawl survey is an absolute index representing 75% of the Greenland turbot stock in US waters. An updated mortality estimate of 0.112 supersedes the 0.18 used in the past. Compared to previous models, selectivity was allowed to change more over time for some surveys and fisheries, resulting in improvements of some residual patterns. The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock. Updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 41,800 t, 0.51, and 0.67, respectively. Projected spawning biomass for 2007 is 60,400 t. Greenland turbot therefore qualify for management under Tier 3a. The maximum permissible value of F_{ABC} under this tier translates into a 2007 ABC of 12,680 t. Because this was the first implementation of the model under SS2, and because of the lack of a slope survey, the author recommended setting the 2007 ABC at a value less than the maximum permissible. Using F_{ABC} = 5-year average catch, results in a 2007 ABC of 2,440 t corresponding to a full selection fishing mortality rate of 0.09. The OFL fishing mortality rate is computed under Tier 3a, $F_{OFL} = F_{35\%} = 0.67$, and translates into a 2007 OFL of 15,600 t.

Arrowtooth flounder - The present assessment continues to utilize catchability as a function of the annual average bottom temperature during the EBS shelf trawl survey and also uses the EBS shelf trawl survey sex ratios as prior information to estimate sex-specific population numbers at age. This year's EBS shelf bottom trawl survey resulted in a biomass estimate of 670,000 t, which is second only to last year's survey as the highest estimate over the time series. The Aleutian Islands trawl survey estimate of 229,000 t was the highest ever estimated in that region. The stock assessment model indicates that the biomass is at its highest level since observations began in 1975 due to episodes of above average recruitment in the 1980s and again in the period 1998 to the present. The stock remains very lightly harvested with fish caught primarily as bycatch in other fisheries. Discarding occurs at a rate exceeding 50%.

Since more female arrowtooth flounder are caught in trawl surveys throughout Alaska compared to males, and because the oldest female fish have been determined to be older than the oldest males, it is hypothesized that there are different natural mortality values for each sex. With the female natural mortality rate fixed at 0.2, male natural mortality was profiled over a range of values to determine which value provided the best fit to all the observable population characteristics and still gave reasonable estimates of male selectivity to the survey trawl. The male natural mortality rate that provided the best fit was 0.33. With the stock assessment model configured in this way, the population biomass was estimated at 1,275,900 t.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying arrowtooth flounder for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 340,000 t, 0.24, and 0.30, respectively. Given that the projected 2007 spawning biomass of 824,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2007 were calculated under sub-tier "a" of Tier 3. The F_{ABC} was set at the $F_{40\%}$ (0.24) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2006 ABC of 158,000 t. The OFL fishing mortality rate under Tier 3a is $F_{35\%}$ (0.30), which translates to a 2006 OFL of 193,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The ABC recommendation is for the combined harvest of arrowtooth flounder and Kamchatka flounder, which are difficult to distinguish and had similar biomass trends from the EBS trawl survey since 1991. Ecosystem considerations of predator-prey dynamics of arrowtooth flounder in the Bering Sea indicated that the top prey species of arrowtooth flounders are juvenile pollock. However, juvenile arrowtooth flounder in the Bering Sea are an important prey for adult pollock. The ramification of increases of one of these species, with decreases of the other, has unknown consequences due to this duality of the predator-prey relationship.

For further information, contact Thomas Wilderbuer (206) 526-4224.

GULF OF ALASKA

Arrowtooth flounder - Since no survey was conducted in the Gulf of Alaska in 2006, projections were made using the 2006 catch and the population age structure in 2005 to give the 2007 ABCs listed below. The 2005 stock assessment is summarized below.

The 2005 arrowtooth flounder assessment featured new biomass and length composition data from the 2005 NMFS bottom trawl survey and updated catch and fishery length data for 2005. The model also includes survey age composition data from each survey except for 2005 (ages not determined yet). The 2005 estimated age 3+ biomass of 2,109,700 mt is based on abundance estimates derived from an age structured model and indicates that the population is at a historical (past 40 years) high level. Data from halibut trawl surveys in the 1960's, groundfish trawls in the 1970's, and NMFS triennial trawl surveys from 1984 to 2005 were included in the model. Similar to the previous assessment, the model matched the observed higher proportion of females in the larger size intervals of both survey and fishery data by allowing males a higher mortality rate than females.

The ABC estimate was based on Tier 3a calculations due to the fact that the estimated 2005 female spawning biomass (1,095,700 mt) is greater than the $B_{40\%}$ estimate (545,900 mt). Therefore, $F_{OFL}=F_{35\%}=0.168$ and $F_{ABC}= F_{40\%} = 0.142$ resulting in an ABC recommendation of 177,844 t. The overfishing level for arrowtooth flounder is estimated to be 207,700 mt. The Plan

Team recommended that ABC be apportioned among regulatory areas in proportion to biomass distributions in the 2005 trawl survey as follows:

Western	Central	West Yakutat	East Yakutat/SE	Total	
20,154	134,907	15,954	6,830	177,844	**2006**
20,852	**139,582**	**16,507**	**7,067**	**184,008**	**2007**

Gulf of Alaska flatfish - The 2005 assessment recommendations used for 2006 were rolled over to 2007 for shallow water flatfish and were increased slightly for deep water flatfish until a new survey is conducted in 2007.

New data for the 2005 flatfish assessment included the 2005 NMFS bottom trawl survey biomass estimates and the 2005 catch. The 2005 survey biomass estimates were used to calculate ABC's for 2006 for all species except Greenland turbot and deepsea sole, where the mean catch from 1978 to 1995 was used. The survey sampled to 700 m depth while the distribution of these deep water species extends deeper. Dover sole, the main constituent of the deep water group, is now assessed in using an age structured model. These stocks remain lightly harvested relative to their estimated biomass because the annual catch is almost always less than the TAC levels which are typically set less than the ABC.

The flatfish group is subdivided into arrowtooth flounder, deep water flatfish, flathead sole, rex sole and shallow water flatfish. Flathead sole and arrowtooth flounder, and rex sole are presented in separate assessments using age-structured models. The 2006 exploitable biomass for each group (except for those species with age-structured models) is based directly on results from the 2005 NMFS trawl survey. ABC and OFL were calculated by species, with individual species identified as Tier 4, 5, or 6 depending upon the available data. The ABC's for northern and southern rock sole were estimated based on Tier 4 with $F_{ABC}= F_{40\%}$ (Southern rock sole $F_{40\%}$=0.162; Northern rock sole $F_{40\%}$=0.204) and $F_{OFL}=F_{35\%}$ (southern rock sole $F_{35\%}$=0.192; northern rock sole $F_{35\%}$=0.245) while other flatfish ABC's were estimated with F_{ABC}=0.75 M and F_{OFL}=M (Tier 5).

The stock assessment model for Dover sole indicated that age 3+ biomass estimates increased slightly while female spawning biomass estimates continue to remain relatively unchanged. Recruitment may have been high in 2002 and catches remain well below the TAC. The 2006 ABC using $F_{40\%}$ = 0.142 was estimated at 8,842 t, which is 1,842 t more than the 2005 ABC. The 2006 OFL using $F_{35\%}$= 0.184 was estimated at 10,764 t.

Greenland turbot and deep-sea sole ABC's were estimated at Tier 6 with ABC=0.75 OFL (183 t) and OFL=average catch from 1978 to 1995 (244 t). Total flatfish ABC for 2006 was 1,225 mt greater than in 2005. ABC's were apportioned among the regulatory areas by applying the average fraction of the survey biomass in each area in 2005. As in 2005, the ABC was split between the eastern GOA and the WY and EYAK/SEO sub areas.

2007 ABC area apportionment

Flatfish group	Western	Central	WYAK	EYAK/SEO	Total
Deep water	420	4,163	2,677	1,447	8,707
Shallow water	24,720	24,258	628	1,844	51,450

Flathead sole - Until new survey information becomes available in 2007, the 2005 assessment model results projected ahead (using the 2006 catch) are used for 2006 management. The 2005 assessment is summarized below.

New data for the 2005 flathead sole assessment included the 2005 survey biomass estimate and length data, and 2005 catch and fishery length data. Maturity parameters were updated and estimates of reference fishing mortality were estimated from spawner per recruit analysis. The 2006 biomass estimate from the age-structured model was 291,400 t, continuing a stable trend since the mid 1980s.

The projected 2006 female spawning biomass is estimated to be well above the $B_{40\%}$ level therefore flathead sole ABC and OFL are calculated using Tier 3a calculations. Under this definition, $F_{OFL}=F_{35\%}$, and F_{ABC} is less than or equal to $F_{40\%}$. The ABC for 2007 using $F_{40\%}$ = 0.36 was estimated at 39,110 mt. The overfishing level using $F_{35\%}$ = 0.46, results in 48,658 mt. Area apportionments of flathead sole ABC's for 2007 (using $F_{40\%}$) are based on the fraction of the 2005 survey biomass in each area:

Western	Central	West Yakutat	East Yakutat/SE	Total
10,908	26,054	2,091	57	39,110

For further information, contact Jack Turnock (206) 526-6549 and William Stockhausen (206) 526-4241.

8. Lingcod

a. Research

Habitat Studies

Relatively little is known about the habitat requirements of juvenile lingcod. Initial laboratory experiments in AFSC's Newport facility demonstrated an affinity for structure (rock, shell, or seagrass) over bare sand habitats. An acoustic tagging study conducted in Yaquina Bay, Oregon, corroborated the basic habitat preferences seen in laboratory experiments. Juvenile lingcod showed a high degree of site fidelity, remaining in discreet areas of significant structural complexity, as evidenced by underwater video of benthic habitat. With this information, we can start to identify what constitutes essential fish habitat for juveniles of this important fisheries species.

For further information, contact Dr. Allan Stoner, (541) 867-0165.

10. Walleye pollock

a. Research

Echo Integration-Trawl Surveys

GULF OF ALASKA

Winter echo integration-trawl surveys in the vicinity of Shumagin Islands and Sanak Trough, Shelikof Strait, and the shelf break near Chirikof Islands - The MACE Program conducted a winter echo integration-trawl (EIT) survey aboard the NOAA ship *Miller*

Freeman, which targeted walleye pollock in the Shumagin Islands, Sanak Trough, and Morzhovoi Bay. The Shumagin Islands portion of the survey was conducted between 15-18 February along parallel transects. Transects were spaced 5-nmi apart within Shumagin Trough, 1-nmi apart east of Renshaw Point, and 2.5-nmi apart elsewhere. The Sanak Trough survey was conducted between 18-19 February along transects spaced 2-nmi apart. Morzhovoi Bay, which was surveyed for the first time, was surveyed on 19 February along transects spaced 2.5-nmi apart

In the Shumagin Islands, the densest pollock aggregations were observed off Renshaw Point, although in significantly less quantities than detected in earlier surveys. Most fish off Renshaw Point exceeded 40 cm FL. Significant quantities of age-1 pollock (8-13 cm FL) were detected in Shumagin Trough. The only other year when juveniles were detected in more than trace amounts was 2001. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 3% developing, 66% pre-spawning, 30% spawning, and <1% spent. The maturity composition of females longer than 40 cm was 0% immature, 3% developing, 92% pre-spawning, 2% spawning, and 2% spent. The mean gonado-somatic index (GSI: ovary weight/body weight) for mature pre-spawning females was 0.13. Pollock EIT survey abundance estimates in the Shumagin Islands area were 1,788 million pollock weighing 37,000 metric tons, based on catch data from 11 trawl hauls and acoustic data from 390 nmi of survey transects. The area off Renshaw Point accounted for 68% of the adult (>40 cm FL) biomass.

The densest pollock aggregations in Sanak Trough, which consisted of only adult pollock, were located in the northern part of the Trough. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 2% developing, 19% pre-spawning, 67% spawning, and 11% spent. The maturity composition of females longer than 40 cm FL was 1% immature, 1% developing, 64% pre-spawning, 7% spawning, and 17% spent. The average GSI for pre-spawning females was 0.16. The abundance estimates for Sanak Trough were 120 million pollock weighing 127,000 t, based on catch data from 4 trawl hauls and acoustic data from 108 nmi of survey transects.

The densest aggregations in Morzhovoi Bay were detected in the mouth of the bay. The unweighted maturity composition for males longer than 40 cm FL was 0% immature, 1% developing, 15% pre-spawning, 79% spawning, and 4% spent. Only four females were collected for length and maturity measurements, thus maturity composition and GSI estimates could not be completed. The abundance estimates for Morzhovoi Bay is 13 million pollock weighing 12,000 t, based on catch data from 2 trawl hauls and acoustic data from 66 nmi of survey transects.

The MACE Program also conducted winter EIT surveys aboard the NOAA ship *Miller Freeman* which targeted walleye pollock along the shelfbreak southeast of Chirikof Island and in the Shelikof Strait area. The survey of the shelf break from southeast of Chirikof Island to near the mouth of Barnabas Trough was conducted during 14-15 March along parallel transects spaced 6-nmi apart. The Shelikof Strait sea valley was surveyed from south of Chirikof Island to north Kuliak Bay on the Alaska Peninsula during 16-27 March along parallel transects spaced 7.5-nmi apart.

Along the Chirikof shelf break, most of the echosign attributed to pollock occurred in midwater layers between 275 and 400 m depth south of the mouth of Barnabas Trough over bottom depths of 300-1,000 m. Pollock size composition in these layers ranged from 45-60 cm with a mode at 49 cm FL. The unweighted maturity composition in the Chirikof Island area for males longer than 40 cm FL was 0% immature, 0% developing, 46% pre-spawning, 54% spawning, and 0% spent. The maturity composition of females longer than 40 cm FL was 0% immature, 2% developing, 98% pre-spawning, 0% spawning, and 0% spent. The high

percentage of pre-spawning females indicates that peak spawning had not occurred. The average GSI for pre-spawning females was 0.14. The pollock abundance estimates for the Chirikof Island area were 61 million pollock weighing 69,000 t, based on catch data from 4 trawl hauls and acoustic data from 162-nmi of survey transects.

In the Shelikof Strait area, dense aggregations of mature, pre-spawning pollock were detected along the northern side of the Strait from Cape Unalishagvak to Katmai Bay, although the abundance was lower than in 2005, which in turn was lower than in the mid-to late-1990s. Adult pollock mixed with age-1 (9-16 cm) and age-2 (17-24 cm) were located on the Kodiak Island side of the Strait as well as south of the mouth of the Strait (between Cape Ikolik and Wide Bay) to near the Semidi Islands. Mid-water layers of age-1 and age-2 pollock were detected primarily in the northern portion of the survey area on the Kodiak Island side of the Strait. The unweighted maturity composition for males longer than 40 cm FL was 3% immature, 4% developing, 60% pre-spawning, 34% spawning, and 0% spent. The maturity composition of females longer than 40 cm FL was 3% immature, 4% developing, 91% pre-spawning, 1% spawning, and 0% spent. These results are similar to previous survey results in terms of the relatively low numbers of spawning and spent female fish, which suggests that the survey timing was appropriate. A logistic model provided a reasonable fit to the female maturity-at- length data and predicted that 50% of females were mature at a length of 43 cm. The average GSI for mature pre-spawning females was 0.14. The pollock abundance estimates for Shelikof Strait were 1.2 billion pollock weighing 294,000 t, based on catch data from 23 trawl hauls and acoustic data from 950-nmi of survey transects.

Summer interaction study between commercial fishing and walleye pollock off East Kodiak - Field work for the fifth year of a fishery interaction study was completed between 13 August and 5 September 2006 off the east side of Kodiak Island in the Gulf of Alaska as a collaborative effort between RACE and REFM scientists from the Alaska Fisheries Science Center. The work is part of a larger program designed to evaluate the effect of commercial fishing activity on the prey availability of walleye pollock (*Theragra chalcogramma*) and other forage fish species to endangered Steller sea lions (*Eumetopias jubatus*).

The principal objective of the experiment was to use standard acoustic survey methods to describe the spatio-temporal variability in pollock abundance and distribution patterns in two troughs over a period of several weeks before and during the commercial pollock fishery. The study area consisted of a site where commercial fishing was allowed (Barnabas Trough), and a comparison site where commercial fishing was prohibited (Chiniak Trough). Repeated survey passes were conducted within each trough before and during the fishery to document if a perturbation occurred in the fish distribution during the fishing period. To characterize the physical environment, oceanographic data were collected using drifters, CTDs, XBTs, and a vessel-mounted thermosalinograph.

Most of the acoustic backscattering was attributed to adult pollock, age-1 pollock, and mixed schools of age-0 pollock and capelin (*Mallotus villosus*). The adults were generally detected as near-bottom schools or as an on-bottom "carpet." As in other years of the study, adult pollock were generally distributed within the northern half of Barnabas Trough and throughout Chiniak Trough. Relatively large, dense aggregations of age-0 pollock/capelin, located in mid-water during daylight, were broadly distributed throughout Chiniak Trough and predominantly in the northern portion of Barnabas Trough. Unlike the deeper dwelling adults, the age-0 pollock/capelin mix often extended over relatively shallow bottom depths of less than 100 m. The presence of relatively large numbers of age-0 pollock during the survey was similar

to what was observed in 2004. Daytime trawl catches often caught more age-0 pollock than capelin, although the selectivity of the AWT to these species is unknown and so it is uncertain whether the different catch rates for these two species groups accurately reflects their relative abundance in the water column.

The size composition of adult pollock ranged between modes of 52-62 cm fork length, larger than adult pollock in 2004. The size composition of age-0 pollock had prominent length modes at 6 or 7 cm standard length, and that of age-1 pollock at 20 to 21 cm.

A total of 589 marine mammal sightings of groups or individuals were made during the survey. A rare sighting of a northern right whale was made in the outer region of Barnabas on 1 Sept (~N 56 47.06, W152 26.18).

Two very localized and persistent vertical sound-scattering "columns" were detected in Barnabas during all passes. The source of these columns is unknown. They may be gas bubbles rising from active geological seeps. The locations of these features are: N57 03.03, W152 42.10 and N56 56.95, W152 25.00.

BERING SEA

Winter echo integration-trawl survey in the southeast Aleutian Basin near Bogoslof Island - The MACE Program conducted an EIT survey aboard the NOAA ship *Miller Freeman* between 4 and 9 March 2006, which targeted walleye pollock in the southeastern Aleutian Basin near Bogoslof Island. The survey comprised 35 north-south parallel transects spaced 3-nmi apart, which covered 1,803 nmi^2 of the Central Bering Sea Convention Specific Area.

As in recent years' surveys, pollock were concentrated in two main regions; northeast of Umnak Island off Cape Idak, and just north of Samalga Pass between the Islands of Four Mountains and Umnak Island. Pollock lengths ranged between 38 cm and 71 cm FL. In the Cape Idak-Umnak Island area, pollock were characterized by a dominant mode at 45 cm FL (representing the 2000 year class), while in the Samalga Pass area pollock aggregations had higher proportions of fish larger than 55 cm FL, generating a bimodal distribution with modes at 47 and 60 cm FL. The unweighted maturity composition for males was 0% immature, 1% developing, 60% pre-spawning, 39% spawning, and less than 1% spent. The female maturity composition was 0% immature, 1% developing, 72% pre-spawning, 6% spawning, and 21% spent. A higher percentage of spent females were captured in the Umnak region than in the Samalga region. The average GSI for mature pre-spawning females was 0.17. The pollock abundance estimates for the southeastern Aleutian Basin area were 239 million fish weighing 240,000 t, based on catch data from 13 trawl hauls and acoustic data from about 732-nmi of survey transects. This was the highest abundance in terms of numbers of fish estimated since the 1999 Bogoslof EIT survey. About 58% of the total biomass was in the Umnak Island area, and 42% in the Samalga Pass region.

Summer echo integration-trawl survey on the eastern Bering Sea shelf - The MACE Program conducted an EIT survey of midwater walleye pollock in the eastern Bering Sea shelf between 6 June and 21 July 2006. The survey design consisted of 28 north-south transects spaced 20 nautical miles (nmi) apart over the Bering Sea shelf from Port Moller, Alaska, to the U.S.-Russia border.

Midwater (near surface to 3 m off the seafloor) abundance estimates were 3.4 billion pollock weighing 1.6 million t based on catch data from 104 trawl hauls and acoustic data from

4477 nmi of survey transects. The biomass was about half of what was observed in 2004 (3.3 million t) and most of it was distributed west of St. Matthew Island. Only about 25% of the estimated biomass was east of 170°W and about 8% of this value was found inside the Steller sea lion Conservation Area (SCA). Although a few juveniles were present east of 170°W, most of the pollock in this region ranged between 35-68 cm FL with a mode at 48 cm FL. West of 170°W, where 75% of the estimated biomass was observed, the pollock length composition primarily ranged between 11-67 cm FL with major modes at 13 cm and 44 cm FL and a minor mode at 23 cm FL.

Population-at-age estimates indicated that pollock from the 2000-2002, and 2004 year-classes made up most of the population. Five-year-old pollock (2001 year class) were estimated to number 695.3 million and weigh 366.4 thousand t, contributing about 20.5% and 23.5% of the total estimated numbers and biomass, respectively. The age-1 pollock estimate of 455.6 million was significantly higher than the estimate in 2004 (15.8 million) and contributed 13.4% of the total estimated population.

Intervessel Comparison - Scientists from the Midwater Assessment and Conservation Engineering (MACE) Program conducted an intercomparison of echo-integration trawl (EIT) survey data between the NOAA ships *Miller Freeman* and *Oscar Dyson* as part of the 2006 EIT survey in the eastern Bering Sea from July 3 to July 13, 2006. The primary goal of this work was to investigate if walleye pollock differentially avoid the two vessels.

Oscar Dyson was designed to meet the ICES specification for underwater radiated noise to minimize vessel avoidance during fish abundance surveys, while *Miller Freeman* is a conventionally built vessel, which exceeds this specification. It is possible that fish will respond to the vessels differently due to the disparate auditory stimuli produced by the vessels. If this is the case, differential vessel avoidance may influence the biomass estimates derived from EIT methods with the two vessels. This is of particular interest for resource management in Alaskan waters as the *Oscar Dyson* is slated to become the primary vessel for pollock EIT surveys, which have historically been conducted aboard *Miller Freeman*.

Both vessels continuously collected acoustic backscatter at 18, 38, 120 and 200 kHz while traveling in close proximity. A two-part study design was developed and implemented by MACE staff, which included a component in which the vessels traveled side by side at a distance of 0.5 nautical miles (nmi). This was designed to allow for concurrent EIT operations without compromising the survey data for use in stock assessment. In addition, a component in which one vessel followed the other at a distance of 1 nmi was implemented in order to investigate the underlying mechanisms for differences in vessel avoidance. Acoustic data collection from both vessels was conducted over a wide range of densities of adult pollock, and conditions typical of acoustic surveys in this area. Paired trawl hauls were also conducted with the vessels separated by 0.5 nmi.

Analysis of these data in collaboration with a visiting scientist from the Institute of Marine Research, Norway began shortly after the cruise and is ongoing. Initial analyses indicate that the acoustic backscatter detected by the two vessels differ in various ways for the four frequencies, but that the differences are due to echosounder differences rather than vessel induced fish behavior. Additionally, analysis of pollock depth distributions from the transects in which the vessels followed each other revealed that when *Oscar Dyson* was leading, the pollock observed by *Miller Freeman* were on average significantly deeper than those observed by *Oscar Dyson*. Because no difference in pollock depth was observed when the *Miller Freeman* was leading, or when the vessels traveled side by side, this change in depth distribution may suggest

that pollock dive in response to the passage of *Oscar Dyson*, with the diving occurring primarily after the fish have been detected in the acoustic beam. Further fieldwork comparing the two vessels is planned for the winter and spring of 2007.

For more information, please contact MACE Program Manager, Chris Wilson, (206) 526-6435.

b. Stock assessments

GULF OF ALASKA

The age-structured model developed using AD Model Builder and used for GOA pollock assessments in 1999-2002 is fundamentally unchanged for the 2006 assessment. This year's pollock assessment features the following new data: (1) total catch and age composition from the 2005 fishery; (2) biomass and age composition from the 2006 Shelikof Strait echo integration trawl (EIT) survey; (3) biomass and length composition from the 2006 ADF&G crab/groundfish trawl survey, and (4) age composition from the 2005 NMFS bottom trawl survey.

The model estimate of spawning biomass in 2007 is 160,670 t, which is 29% of unfished spawning biomass and below $B_{40\%}$ (220,000 t), thereby placing Gulf of Alaska pollock in sub-tier "b" of Tier 3. Estimates of stock status in 2007 indicate a 16% decline in spawning biomass from 2006. These results are consistent with survey trend estimates (13% decline in the Shelikof Strait EIT survey, 13% decline in the ADFG trawl survey). The dip in spawning biomass is expected to be short-lived, as projections indicate an increase in spawning biomass after 2007. These results depend critically on the magnitude of the 2004 year class, which appears to be above average, but is still uncertain. The author's 2007 ABC recommendation for pollock in the Gulf of Alaska west of 140° W longitude is (W/C/WYK) is 63,800 t, a decrease of 22% from the 2006 ABC. This recommendation is based on a more conservative alternative to the maximum permissible F_{ABC} introduced in the 2001 SAFE. The OFL in 2007 is 87,220 t. In 2008, the recommended ABC and OFL are 76,960 t and 105,490 t, respectively.

While there were no additions to the pollock stock assessment ecosystem considerations section this year, pertinent information for GOA pollock was presented within the Ecosystem Considerations Section (SAFE Appendix C). A new analysis conducted with the GOA ecosystem model compared estimates of predation mortality and fishing mortality relative to population production in order to determine whether total mortality exceeded production. The results suggested that high predation mortality plus conservative fishing mortality might exceed GOA pollock production at present (Ecosystem SAFE Figure 9), and that this condition may have been in place since the late 1980's or early 1990s (Ecosystem SAFE Figure 7). Although this analysis was considered preliminary by the ecosystem assessment authors, the Plan Team felt that it provided additional support for continued precautionary management of GOA pollock. The Plan Team concurred with the author's choice to use the same model as last year to provide assessment advice. This model fixed trawl survey catchability (q) at 1.0 and estimated other catchabilities. Although the likelihood is higher for models with q closer to 0.8, the change in likelihood is small (less than 1) between models with q fixed at 1.0 or estimated. Fixing q at 1.0 results in a more precautionary estimate of spawning biomass and therefore ABC than other models. Furthermore, identical to last year, the Plan Team accepted the author's recommendation to reduce ABC from the maximum permissible using the "constant buffer" approach (first accepted in the 2001 GOA pollock assessment). Therefore, the ABC for 2007 based on this

precautionary model configuration and adjusted harvest control rule is 62,150 mt (F_{ABC} =0.16) for GOA waters west of 140 degrees W. longitude (Note that this ABC recommendation is already reduced by 1,650 mt to account for the Prince William Sound GHL).

The model results produced an estimated 2007 spawning biomass of 160,670 mt, or 29% of unfished spawning biomass. The $B_{40\%}$ estimate is 220,000 mt. Because model estimated 2007 female spawning biomass is below $B_{40\%}$, Gulf of Alaska pollock are in Tier 3b. The projected 2007 age-3+ biomass estimate is 833,710 mt. Markov Chain Monte Carlo analysis indicated the probability of the stock being below $B_{20\%}$ to be less than 1% in 2006 and subsequent years. The 2006 OFL under Tier 3b is 87,220 mt (F_{OFL} = 0.23). Spawning biomass is projected to increase after 2008 in part because of the estimated above average 2004 year class, which is included in projections.

Southeast Alaska pollock are in Tier 5 and the ABC and OFL recommendations based on natural mortality (0.30) and the biomass from the 2005 survey: This results in a **2007 ABC of 6,157 t** (27,362 t *0.75 M), and a **2007 OFL of 8,209 t** (27,362 t * M)**.** Since no new survey data will be available until the summer of 2007, the 2008 ABC and OFL should be set equal to the 2007 values for the E.Yak/SE area. The assessment was updated to include the most recent data available for area apportionments within each season (Appendix C of the GOA pollock chapter).

For more information contact Dr. Martin Dorn 526-6548.

EASTERN BERING SEA

The Eastern Bering Sea Pollock resource remains at a high and stable level while sustaining average annual harvest levels greater than 1 million tons. The 2006 stock assessment incorporated revised estimates of age composition from the 2006 Echo integration survey (EIT) as well as the 2006 bottom trawl survey estimate and the 2006 fishery information.

The bottom trawl survey biomass estimate from the standard area (strata 1-6) was 2.85 million t, down by 45% from the 2005 estimate of 5.13 million. This survey estimate is about 59% of the average of all BTS estimates since 1982. The 2006 echo-integration trawl (EIT) survey numbers-at-age estimates were also low with a biomass estimate (1.56 million t) nearly as low as the 1991 value (1.45 million t). Projections for 2007 indicate that the stock is close to or slightly below the B_{MSY} level and will continue to drop given the current age structure estimate. The survey data do indicate that the 2005 year class may be near or above average, but this is highly uncertain.

Three alternative models are presented, all of which follow the statistical age-structured approach that has been used for the last several years. All of these models give point estimates of 2007 age 3+ biomass in the range 6,100,000 t to 6,360,000 t (Table 1.16, Models 1 and 2 only). The author recommends Model 2, which differs from last year's base model (Model 1) by the addition of data from the northwest area of the bottom trawl survey (strata 8 and 9). This increases coverage of the current range of pollock. The current assessment provides estimates of age-3+ biomass that are very close to those provided in last year's assessment. While the 2000 year class appears much stronger than average, most other year classes spawned after 1996 appear weaker than average, with the exception of the 1999 and 2005 year classes, which appear average.

The SSC has determined that reliable estimates of B_{MSY} and the probability density function for F_{MSY} exist for this stock. Therefore, EBS walleye pollock qualify for management under Tier 1. The assessment authors' has concluded that the Tier 1 reference points are reliably

estimated given the structure of the model. The updated estimate of B_{MSY} from the present assessment is 2,060,000 t, compared to 2,120,000 t from last year's assessment. The projected spawning biomass for 2007 is 2,170,000 t, placing EBS walleye pollock in sub-tier "a" of Tier 1. As in the last three assessments, the maximum permissible ABC harvest rate was based on the ratio between MSY and the equilibrium age 3+ biomass corresponding to MSY. The harmonic mean of this ratio from the present assessment is 0.243, virtually identical to the value obtained in last year's assessment. This ratio is multiplied by the geometric mean of the projected age 3+ biomass for 2007 to obtain the maximum permissible ABC for 2007, which is 1,510,000 t. This ABC is about 8% higher than the 2007 yield corresponding to an $F_{40\%}$ strategy, which is 1,390,000 t. For the last five years, ABC for this stock has been set at the maximum permissible value. This year, the assessment authors recommend setting ABC at 1,300,000 t, rather than at the maximum permissible value. Several reasons were cited for recommending an ABC less than the maximum permissible value of 1,510,000 t. In 2006, fishing vessels needed to travel farther to catch pollock, lower abundances of pollock than expected were observed for both the bottom trawl survey and the EIT survey, some evidence exists for recently lowered Bering Sea productivity (reduced zooplankton and forage fish abundance as shown in this year's Ecosystem Considerations Chapter), and arrowtooth flounder, which is an important predator of pollock, is increasing. A catch of 1,300,000 t would maintain the spawning exploitation rate at the current level. In contrast, the $F_{40\%}$ ABC recommendation of 1,390,000 t and the maximum permissible value of 1,510,000 t would increase spawning exploitation rate to the highest values since 1980. On the other hand, an ABC of 1,300,000 t does not preserve markedly more spawning biomass compared to the $F_{40\%}$ ABC recommendation of 1,390,000 t. One reason was cited for recommending an ABC equal the maximum permissible value; the 2007 female spawning biomass is near B_{MSY}, which is the target spawning biomass. The Plan Team chose to accept the senior author's recommendation of 1,300,000 t for an ABC less than the maximum permissible value and to maintain the spawning exploitation rate at the current level. However, the North Pacific Management Council set the 2007 ABC at 1,394,000 t with an OFL of 1,640,000 for the eastern Bering Sea portion of the stock.

ALEUTIAN ISLANDS

For many years, the Aleutian Islands pollock stock has lacked an age-structured model and the SSC has determined that the stock qualified for management under Tier 5. Following preliminary exploration of some age-structured models in the 2003 assessment, several models were presented for potential management use in recent years' assessments. However, the SSC concluded that adoption of a model was precluded until such time as additional field research results in greater confidence in the stock structure and spatial distribution of Pollock in the Aleutian Islands. An experimental survey (AICASS) conducted by the senior assessment author provides research to help resolve the ambiguities in pollock stock structure and may also facilitate exploration of alternative management systems based on finer spatial-temporal scales. The Plan Team supports continuation of these studies as well as genetic studies to resolve pollock stock structure. In this year's assessment, two models from last year's assessment are presented. Model 1 uses data only from the portion of the stock to the west of 174°W and Model 2A includes survey data from the entire Aleutian Islands management area. However, the same ambiguities of stock structures and dynamics present in last year's assessment remain. As a result, the Plan Team does not support using the models to estimate Aleutian Islands pollock abundance. A third model (Model 2B) was presented that also estimates natural mortality within

Model 2. The senior author's preferred model is Model 2B. The estimate of $M = 0.235$ appears more credible than the value of 0.3 assumed for previous assessments. The posterior distribution of M is relatively narrow, implying that the estimate of M is precise. In addition, ecosystem modeling indicates that pollock natural mortality is less in the Aleutians than in the Bering Sea.

The SSC has determined that the Aleutian pollock stock qualifies for management under Tier 3 and set the 2007 ABC at 44,500 t and the OFL at 54,500 t.

BOGOSLOF

The 2006 hydroacoustic survey of the Bogoslof region resulted in a biomass estimate of 240,000 t, a decrease of about 5% from the 2005 estimate. The SSC has determined that Bogoslof pollock qualified for management under Tier 5. The maximum permissible ABC under Tier 5 is 75% of the product of the natural mortality rate (0.20) and biomass, giving a value of 36,000 t. For several years, the SSC has used a much more conservative approach. The SSC formula uses a biomass-adjusted harvest rate rule (with 2,000,000 t estimate as a reference stock size) and an estimate of F_{ABC} based on growth, natural mortality, and maturation rate. If the formula used by the SSC is applied, the resulting fishing mortality rate is 0.022, giving a 2007 ABC of 5,220 t. The overfishing level under Tier 5 is the product of the natural mortality rate and biomass, giving an OFL of 48,000 t for 2007. As a Tier 5 stock, it is not possible to determine whether Bogoslof pollock is overfished or whether it is approaching an overfished condition. Two age-structured models were presented in this year's assessment. Survey catchability was assumed equal to 1.0 in both models. The two models differed in whether a portion of Donut Hole catches were excluded (Model 1) or included (Model 2). Both models imply that age 5+ biomass peaked in 1983 supported largely by an enormous 1978 year class. The 1978 year class appears to have been more than 5 times larger than any subsequent year class. Following a decline from the 1983 peak, biomass appears to have been fairly stable since about 1992. The authors have made an excellent start on age-structured modeling of this stock and provide some useful insights into the history of the stock; however, adoption of any of the models would be premature. In part, the portion of the catch data from the "Donut Hole" area to include in the model is uncertain. In addition, whether pollock in the Bogoslof region can be usefully modeled as a closed stock is uncertain as the amount of interchange with pollock in the Bering Sea is unknown.

For further information contact Dr. James Ianelli, (206) 526-6510.

11. Dogfish

a. Research

NMFS Auke Bay Laboratory and University of Alaska Fairbanks Joint Research on Spiny Dogfish in the Gulf of Alaska

Scientists from the NMFS Auke Bay Laboratory, the University of Alaska School of Fisheries and Ocean Sciences, and the University of Washington School of Aquatic and Fishery Sciences continued a joint study on spiny dogfish (*Squalus acanthias*) in the Gulf of Alaska.

Little is known about the life history or ecological role of spiny dogfish in the North Pacific despite the fact that they comprise a relatively large biomass in coastal northeast Pacific waters. One aspect of this research is to collect a time series of life history and ecological information from spiny dogfish in Yakutat Bay where they are commonly encountered as bycatch.

In 2006, a joint special project was completed with the NMFS Alaska Observer Program to collect length and maturity from random incidental catches of spiny dogfish in commercial fisheries for groundfish in the Gulf of Alaska. Length frequency and maturity data are being analyzed and will be summarized in the annual Stock Assessment and Fishery Evaluation (SAFE) report for sharks in the Gulf of Alaska.

For more information, contact Dean Courtney at (907) 789-6006.

13. Skates

a. Research

Skate reproductive ecology

Gerald Hoff successfully defended his Ph.D. entitled "Reproductive Biology of the Alaska Skate *Bathyraja parmifera*, with regard to Nursery Sites, Embryo Development and Predation" on January 26, 2007. Dr. Hoff began his graduate studies in the fall of 2003 at the University of Washington in the School of Aquatic and Fishery Sciences under the direction of Dr. Ted Pietsch. Dr. Hoff has been a Research Fisheries Biologist in the RACE Bering Sea Groundfish Division at the Alaska Fisheries Science Center since 1997.

His research focused on characterization of an Alaska skate nursery site located in the southeastern Bering Sea. The research identified the nursery extent and habitat type, and included seasonal sampling to determine the timing of reproduction and egg deposition; timing of embryo hatching; and mortality sources to young skates. Jerry has 6 manuscripts in the works that are in various stages of preparation and review:

1. Embryo development of the Aleutian Skate and the Alaska Skate
2. Characterization of a Nursery Site for the Alaska Skate *Bathyraja parmifera*
3. Skate Egg case predation in the Eastern Bering Sea
4. Emerging patterns of species richness and density in the skates (Rajidae) of Alaska
5. Life History Parameters of Eight Skates from the Eastern Bering Sea
6. Characterization of Skate Nurseries in the Eastern Bering Sea

For more information, contact Dr. Jerry Hoff at (206)526-4580.

14. Other Species

a. Research

Electronic Tagging of Pacific Sleeper Shark in Upper Chatham Strait, Southeast Alaska

Scientists from the NMFS Auke Bay Laboratory continued electronic tagging studies of Pacific sleeper sharks (*Somniosus pacificus*) in the Gulf of Alaska. Pacific sleeper sharks are a deepwater shark of the North Pacific Ocean. Little information is available for Pacific sleeper sharks, although they are considered common in boreal and temperate regions of shelf and slope waters of the North Pacific. Pacific sleeper sharks are captured incidentally in commercial longline fisheries for halibut and sablefish in the Gulf of Alaska. Pacific sleeper sharks are not retained in commercial fisheries, but the incidental bycatch provides an opportunity for tagging research. The recovery of temperature, depth, and location from electronic tags will aid in the identification of Pacific sleeper shark habitat utilization and distribution, and identify potential interactions between Pacific sleeper sharks and other species in the Gulf of Alaska.

In 2006, a total of 10 Pacific sleeper sharks were captured in upper Chatham Strait, Southeast Alaska aboard the chartered commercial fishing vessel *Sea View*. Average length was 233 cm for males and 196 cm for females. Electronic satellite pop-up archival tags were attached externally to the first dorsal fin of 4 Pacific sleeper sharks. The tags were programmed to release automatically in June 2007. Archived temperature and depth data along with the location of the tag at the time it reaches the surface will be recovered by satellite.

For more information, contact Dean Courtney at (907) 789-6006.

Atka mackerel reproductive ecology and use of passive acoustics for studying spawning EFH

Bob Lauth has one manuscript in press with Alaska Fisheries Research Bulletin entitled, "Geographic distribution, depth range, and description of Atka mackerel *Pleurogrammus monopterygius* nesting habitat in Alaska", and another in review with US Fishery Bulletin entitled "Reproductive cycle of Atka mackerel (*Pleurogrammus monopterygius*) in Alaska". Together, these 2 manuscripts provide the most extensive examination of Atka mackerel reproductive ecology conducted to date. Research provided from this study will be very useful to stock assessment biologists and managers for improving the Atka mackerel stock assessment and developing more prudent harvest management strategies.

A new area of interest is the relatively new and rapidly emerging field of passive acoustics. It promises tremendous potential for studying spawning essential fish habitat (EFH). From 7-9 February, Lauth attended a workshop on Underwater Passive Acoustic Monitoring for Remote Regions. The workshop was sponsored by the Alliance for Coastal Technologies (ACT) and was conducted at the Hawaii Institute of Marine Biology. The workshop provided an opportunity to meet other research scientists in the field and learn more about the passive acoustic tools being used. By collaborating with scientists and technology developers, Lauth was able to build a low cost (<$1000) underwater passive acoustic device for listening to fish. He is currently working with the RACE Fisheries Behavioral Ecology Program in Newport, OR and the Alaska SeaLife Center in Seward, AK to record fish sounds both *in situ* and in the laboratory.

For more information, contact Bob Lauth at (206) 526-4121.

b. Stock Assessment

Shark Bycatch in Alaskan Waters

The shark bycatch assessment chapters from 2005 for the Bering Sea/Aleutian Islands (BSAI) and for Gulf of Alaska (GOA) were updated for 2006 and presented to the North Pacific Fishery Management Council's Groundfish Plan Teams in November 2006.

Incidental catch estimates for sharks are now available from the NMFS Alaska Regional Office (AKRO). Incidental catch for sharks was updated with the most recent AKRO estimates, and incidental catch from the years 1997–2005 was established as a baseline for identifying options for setting future sustainable incidental catch limits for sharks in the BSAI and GOA. Bottom trawl survey biomass data were updated for the 2006 Eastern Bering Sea (EBS) shelf and Aleutian Islands. Previous survey data were available from NMFS AFSC bottom trawl surveys in the EBS shelf (1979–2005), EBS slope (historical 1979-1991, and new time series 2002, 2004), and Aleutian Islands (1980–2004). GOA bottom trawl survey biomass data were updated for 2005. Previous trawl survey data were available from NMFS AFSC bottom trawl surveys conducted triennially and biennially in the GOA (1984–2003).

There are currently no directed commercial fisheries for shark species in federally or state managed waters of the BSAI or GOA, and most incidentally captured sharks are not retained. In the BSAI, average incidental catch of Pacific sleeper sharks from 1997–2005 (445 mt) represented 2.5% of the available Pacific sleeper shark biomass from BSAI bottom trawl surveys in 1996–2006 (total of the average biomass from three surveys was 17,647 mt). Historically, BSAI survey catches of Pacific sleeper sharks were rare, and abundance trends from the surveys were unreliable as evidenced by the high uncertainty in the biomass estimates. However, the new EBS slope bottom trawl survey (2002 and 2004) showed a substantial biomass of Pacific sleeper sharks on the EBS slope in 2002 (25,445 mt) but not in 2004 (2,260 mt). The EBS slope survey was not conducted in 2006 because of budget constraints. Spiny dogfish and salmon sharks were rarely encountered in commercial fisheries or bottom trawl surveys in the BSAI. Therefore, spiny dogfish and salmon sharks were not assessed separately in the BSAI.

In the GOA, average bycatch of spiny dogfish from 1997–2005 (422 mt) represented less than 1% of the available spiny dogfish biomass from GOA bottom trawl surveys in 1996–2005 (average biomass of spiny dogfish in the surveys was 47,733 mt). The 2001 survey did not include all areas of the Eastern GOA; hence, it may not be comparable with the other surveys for species such as spiny dogfish which appear to be relatively abundant in the Eastern GOA. Average bycatch of Pacific sleeper sharks from 1997–2005 (313 mt) represented less than 1% of the available Pacific sleeper shark biomass from GOA bottom trawl surveys 1996–2005 (average biomass of Pacific sleeper sharks was 37,459 mt). Average bycatch of salmon sharks from 1997–2005 (63 mt) was relatively small, and GOA bottom trawl survey biomass estimates for salmon sharks were unreliable because salmon sharks were only caught in four hauls from 1996–2005.

For more information, contact Dean Courtney at (907) 789-6006.

Grenadiers in Alaska

In 2006, a comprehensive assessment was done for the first time for grenadiers in Alaska and incorporated as an appendix into the North Pacific Fishery Management Council's (NPFMC) annual Stock Assessment and Fishery Evaluation Report. This assessment was needed because of the possible inclusion of grenadiers in the NPFMC's Groundfish Management Plans and also because of the relatively large numbers of grenadiers that are taken as bycatch in other directed fisheries. Presently, grenadiers are not "specified" in these management plans. Thus, no previous assessments have been done, fishermen are free to catch as many of these fish as they want, and there is no official tracking of catch by management.

Giant grenadier (*Albatrossia pectoralis*) appears to be the only grenadier species to warrant management concern in Alaska at present. Survey information indicates that giant grenadier is the most abundant fish on the continental slope at depths 400-1,000 m in all surveyed areas of Alaska except the eastern Gulf of Alaska. As such, it has a significant role in the slope ecosystem and is an important predator in this habitat. Although there has been little or no directed fishery for giant grenadier in Alaska, substantial numbers are taken as bycatch and discarded in the sablefish and Greenland turbot longline fisheries. Discard mortality is 100%. Estimated annual catches of giant grenadier in Alaska based on observer data have ranged between 11,000 mt and 21,000 mt in the years 1997-2005. By geographic region, these catches averaged 3,154 mt in the eastern Bering Sea (EBS), 2,358 mt in the Aleutian Islands (AI), and 10,903 mt in the Gulf of Alaska (GOA).

In the assessment, data from AFSC bottom trawl and longline surveys were used to compute corresponding biomass estimates of giant grenadier as follows: EBS, 546,453 mt; AI, 1,363,858 mt; and GOA, 486,627 mt. The assessment applied an F=M=0.057 approach to these biomass estimates to compute overfishing levels (OFLs) for giant grenadier in each region, and then multiplied the OFLs by 0.75 to compute the following ABCs: EBS, 23,361 mt; AI, 58,305 mt, and GOA, 20,889 mt. When these values are compared with the estimated catches of giant grenadiers, it appears that giant grenadiers are not being overfished at this time. However, the reported longevity, slow growth, and deep-sea habitat of this species makes it susceptible to overfishing. Furthermore, a high proportion of the catch is likely female because mostly female giant grenadier live at the depths where the commercial fishery operates. Disproportionate removal of females by the fishery could put stocks of giant grenadier at greater risk. Because of these special concerns for susceptibility of giant grenadier to overharvest, fishery managers should closely monitor future catches to ensure that overfishing does not occur.

In addition to the stock assessment of giant grenadier, a field and laboratory study is currently in progress on the reproductive biology of this species, and experimental ageing has also been done. Observations of female and male sexual maturity taken during the annual AFSC longline survey in 2004-2006 suggest that nearly all the fish caught in the commercial fishery are mature. Preserved ovaries are being sampled in the laboratory to determine fecundity, to collect histological samples for maturity verification, and to investigate whether giant grenadier are determinate or indeterminate spawners. The first experimental ageing of giant grenadier by the AFSC's REFM Division Age and Growth Task was completed in 2006-2007, and based on a sample of 357 fish, maximum age was 58 years. This is nearly the same as the maximum age of 56 years reported in the only other ageing study of giant grenadier that has been done in the NE Pacific.

For more information, contact Dave Clausen at (907) 789-6049.

D. Other Related Studies

Population Structure of Forage Fish in Alaskan Waters Using Genetic Methods

Forage fish are a critical food source for many seabirds, marine mammals, and other fish species in the North Pacific Ocean and Bering Sea. Several species support small local coastal fisheries. A forage fish species category was created in 1998 for the Bering Sea/Aleutian Islands and Gulf of Alaska Fishery Management Plans, but little is known about the population structure of forage fish species in these regions. As a step toward better understanding these important prey species, we have begun to examine population structure using genetic methods. The genetic structure reflects the spatial scale of productivity, which is important in developing management policies. Opportunistic sampling from various research surveys in recent years has provided collections of several forage fish species from the Bering Sea, Gulf of Alaska, and coastal waters of SE Alaska. We have archived tissue samples from eulachon (*Thaleichthys pacificus*), capelin (*Mallotus villosus*), Pacific sandlance (*Ammodytes hexapterus*), surf smelt (*Hypomesus pretiosus*), and Pacific sardine (*Sardinops sagax*).

Preliminary laboratory analysis has focused on capelin. Samples from Bering Sea and southeast Alaska collections are being analyzed for a suite of about 30 microsatellite DNA markers. Initial results suggest strong population genetic structuring at this geographic scale.

For more information, contact Sharon Hawkins at (907) 789-6081.

Seasonal Distribution, Habitat Use, and Energy Density of Forage Fish in the Nearshore Ecosystem of Prince William Sound, Alaska

Nearshore waters of Prince William Sound (PWS) provide habitat for forage fish species that are important in the diet of marine mammals, sea birds, and other fishes. Nearshore fishes were sampled at eight locations in western PWS in April, July, and September 2006. At each location, fish were sampled with a beach seine in three shallow water (<5 m deep) habitats (eelgrass, kelp, bedrock outcrops) and with a small purse seine in two sites outside the effective depth range of the beach seine (6-20 m; mostly steep bedrock walls). A total of 17,788 fish representing 45 species were captured in 71 beach seine hauls, whereas 853 fish representing 8 species were captured in 32 purse seine hauls. Of the total catch of fish by beach seine, 49% were captured in kelp, 44% in eelgrass, and 7% in bedrock outcrops. Total catch by beach seine (all habitat types) increased seasonally (4,653 fish in April, 5,274 fish in July, 7,861 fish in September); this indicates that fish occupy shallow, nearshore waters for at least several months a year. More importantly, species composition changed with season: pink salmon dominated catches in April, saffron cod in July, and capelin in September. Larval or juvenile stages of pink salmon, capelin, saffron cod, and Pacific herring accounted for 87% of the total catch (beach and purse seine). For forage fish, catches of capelin and herring were highest in kelp and eelgrass. Nearshore vegetated areas provide habitat for juvenile capelin and herring, particularly in summer and early fall in western PWS.

In July and September, we collected crescent gunnels (n = 141), saffron cod (n = 175), walleye pollock (n = 124), and Pacific herring (n = 172) from eelgrass, kelp, and bedrock habitats to investigate quality of habitat on Fulton's condition factor, growth (RNA/DNA

analysis), and lipid and energy content. In order to maximize the number of observations in each habitat, we used bio-impedance analysis (BIA) to predict dry mass and lipid and energy content. Preliminary analyses (July only) indicate that there was no effect of habitat on length adjusted dry mass of any species. For crescent gunnels, however, Fulton's condition factor depended on habitat ($P = 0.042$); this suggests crescent gunnels take on water weight in bedrock habitats. Habitat type had no effect on Fulton's condition for the other species. Initial examination of BIA calibrations indicates that the relationship relating BIA response to dry mass is species specific.

For more information, contact Scott Johnson at (907) 789-6063.

Larval fish vision and ecology

Lyle Britt is nearing completion of his PhD at the University of Washington School of Fisheries. His thesis research focuses on larval fish vision with particular emphasis on ontogenetic spectral shifts in light sensitivity during different life history stages. Lyle uses specialized techniques at the UW Friday Harbor Laboratory that require fish husbandry, micro-dissention of eyes from fish, and custom photometric laboratory equipment to conduct his experiments. He has collected over 36,000 microspectrophotometry measurements from individual rod and cone cells of more than 50 marine fish species in the Pacific Northwest. Lyle currently has 2 manuscripts in review that investigate the ontogenetic changes in the eye pigments of larval and juvenile lingcod, and hypothesize how lingcod may use ultra-violet light to gain advantage during their critical larval stage. This shift is quite pronounced for lingcod, which display sensitivity to UV light early in their lives when they feed on epipelagic zooplankton, but later lose this sensitivity when they become piscivorous. Lyle has also been working on other hypotheses about how larvae may use low wavelength and depolarized light for targeting prey fields in the open water. Lyle's unique approach of integrating the field and laboratory studies was a hallmark of his late friend, mentor, and major professor, Dr. Bill McFarland. To commemorate him, Lyle helped pull together a Symposium during the Ecology and Evolutionary Ethology of Fishes conference at Soka University in June 2006. Lyle is currently teaching a course on fish and invertebrate vision and ecology at the Friday Harbor Laboratory.

For more information, contact Lyle Britt at (206) 526-4501.

RACE Habitat Research Team

Research by the RACE Division Habitat Research Team (HRT) addresses Congressional mandates to describe and identify essential fish habitat (EFH) of federally managed species in Alaska. In practice, systematic trawl survey data are used to designate EFH as those areas supporting the highest relative abundance. This presumes that density data reflect habitat utilization, and the degree to which a habitat is utilized is assumed to be indicative of habitat value. Subsequent characterization of the habitat in these areas requires systematic mapping of the relevant biotic and abiotic variables.

The research themes of the HRT include: (1) the identification of suitable predictor variables for building habitat models, (2) the development of tools for mapping them over large areas, and (3) the investigation of activities with potentially adverse effects on EFH, such as

bottom trawling. In FY06, the focus was on investigating the utility of acoustic backscatter as a habitat predictor. Major milestones during this period were the completion of: (1) the multi-mission hydrographic-fisheries experiment ("FISHPAC") in the southeastern Bering Sea; and (2) statistical analyses of the relationship between groundfish distributions and acoustic backscatter from a side scan sonar pilot experiment in Bristol Bay. Steady progress is being made on: (1) the spatial modeling of the relationship between groundfish distributions and acoustic data from a single-beam echosounder; and (2) building a knowledge base on the ecology of benthic invertebrates for habitat research. Processing and preliminary analysis have begun on the large quantity of acoustic and biological data collected during FISHPAC with forthcoming results.

2006 HRT Research Activities

Long-range fisheries sidescan sonar (LRSSS) R&D - The broad scope of the EFH mandate requires an efficient process for identifying and mapping habitat. Although research indicates surficial sediments affect the distribution and abundance of many groundfish species, direct sampling with benthic grabs and remote sensing with multibeam echosounders are prohibitively expensive over large areas. The development of a Long Range Side Scan Sonar (180 kHz) capable of very broad coverage (1.5 km swath) addresses the need for greater efficiency when mapping and characterizing the seafloor for fisheries and habitat research. Research and development of the LRSSS and its fiber-optic interface has been progressing since 2004. A prototype LRSSS was successfully deployed and data were acquired during the 2006 FISHPAC experiment in the southeastern Bering Sea. In addition to side scan sonar, the LRSSS towfish also carries an independent single beam echosounder, an integrated multibeam echosounder, and a triplet of optical scatter sensors that measures the concentration of chlorophyll-a, dissolved organics and total particulates.

Acoustic backscatter for Essential Fish Habitat characterization (FISHPAC) - The first FISHPAC field experiment was conducted in the southeastern Bering Sea in the summer of 2006 aboard the NOAA ship FAIRWEATHER[1]. The scientific objective of the cruise was to evaluate the utility of acoustic backscatter data for characterizing EFH, while simultaneously comparing the performance of five different sonar systems. The five systems included two hull-mounted multibeam echosounders on FAIRWEATHER (50 kHz, 100 kHz); a high-resolution interferometric side scan sonar (455 kHz), the prototype LRSSS (180 kHz), and a vertical incidence echosounder (38 kHz) mounted on the LRSSS towfish. Multiple passes were made along 720 nm of survey tracklines spanning strong gradients of groundfish abundance that are represented in a time series of fixed-station annual trawl survey catches. Three sampling devices - (1) a Free Fall Cone Penetrometer (FFCPT), (2) a SEABed Observation and Sampling System (SEABOSS), and (3) a Towed Auto-Compensating Optical System (TACOS) - were used at selected stations on the tracklines to groundtruth acoustic backscatter and assemble a mutifaceted understanding of the seafloor. The performance of each acoustical system will be evaluated based on the degree of statistical correlation between normalized backscatter and fish density. The benefits and costs of each system will be compared to identify the most appropriate system for broad-scale mapping of the Bering Sea shelf. Acoustic data are being processed in collaboration with FISHPAC research partners: the University of New Hampshire Center for Coastal and Ocean Mapping and the NOAA Pacific Hydrographic Branch. FFCPT data

[1] See http://www.afsc.noaa.gov/RACE/surveys/cruise_archives/cruises2006/2006_FW_FISHPAC.pdf

processing and sediment grain size analysis have been completed. Infauna identification in collaboration with scientists in the AFSC Resource Ecology and Fisheries Management (REFM) division is near completion, as well as the analysis of TACOS and SEABOSS imagery.

Short-term trawling effects and recovery monitoring in the eastern Bering Sea - This ongoing multi-year study is a process-oriented investigation of short-term effects and recovery using a BACI experimental design. The study area is located within the Crab and Halibut Protection Zone 1 closed area in Bristol Bay. During a 35-day cruise in 2001, 6 pairs of predesignated 10-mi long research corridors were sampled before and after a trawling disturbance with commercial gear (NETS 91/140 Aleutian cod combination). Quantitative assessments of epifauna and infauna populations were undertaken before and after trawling. The experimental and control corridors were also surveyed before and after trawling using a Klein 5410 side scan sonar system. The corridors were revisited in 2002 to monitor recovery. Preparations are underway to conduct the final sampling event in Summer 2009.

Evaluating single beam echosounders for synoptic seabed classification - Nearly 8 million digitized echo returns from the seafloor were simultaneously collected at two frequencies (38 and 120 kHz) along a 9,000 nm trackline in the eastern Bering Sea (EBS) during a 1999 hydroacoustic fishery survey on the NOAA ship MILLER FREEMAN. Collaborative research with QTC has resulted in a fully-automated objective classification process involving a new application of the Bayesian Information Criterion (BIC). An optimal classification scheme for the EBS shelf has been identified (14 distinct classes of bottom types for 38 kHz data) and these results have been merged with 23 years of RACE trawl survey data from the EBS shelf (1982-2004). The acoustic data have also been processed with QTC algorithms to produce continuous variables, namely the three principal components. Statistical analyses using GAM methods are being conducted to examine the degree to which acoustic variability (as a proxy for seabed properties) corresponds to the distribution and abundance of groundfish and benthic invertebrates.

Reconnaissance mapping with side scan sonar - A reconnaissance of Bristol Bay seafloor habitats was undertaken in 2002 using a high-resolution 455 kHz side scan sonar (Klein model 5410). The reconnaissance effort was centered on an 800 mi^2 area of central Bristol Bay that has never been surveyed by NOAA hydrographers. A 150 m swath of bathymetric data and imagery was collected along survey lines totaling nearly 600 linear miles. In addition to providing spatial context for the ongoing trawl impact study in Bristol Bay, the survey also intersected 18 RACE Division trawl survey stations and followed 78 mi of seabed previously classified using a *QTC View* single beam acoustic system. Imagery was systematically groundtruthed using an underwater video camera and van Veen grab samples. These survey data are being used to investigate whether broad-scale, remotely-sensed acoustic data measure seabed properties that are important to marine species. Statistical analysis indicates that seabed parameters derived from *QTC SIDEVIEW* processing of side scan backscatter images explain a significant portion of the variability in groundfish and invertebrate distributions. This suggests that inclusion of acoustic variables will improve the quality of quantitative habitat models. A report on these findings is presently undergoing AFSC internal review and will subsequently be submitted for peer-review publication.

Benthic invertebrate ecology knowledge base - Benthic invertebrates constitute the living component of benthic habitat, functioning as predators, prey, competitors, and shelter for managed species. They are indicators of environmental conditions and a driving force behind the distribution of managed species. Recognizing the need for ecological information on benthic invertebrates in the Bering Sea to support habitat and fisheries research, a knowledge base is being compiled, including: (1) a comprehensive guide to the life history and ecology of key epibenthic macro-invertebrates; (2) a database of EBS infauna (mainly polychaetes) from grab samples collected during HRT trawl impact studies and the FISHPAC project.

For further information, contact Dr. Bob McConnaughey, (206) 526-4150.

Research Related to Improving Bottom Trawl Surveys

Availability of Pacific cod and Pollock to Bottom Trawl Survey Gear

Understanding survey trawl catchability can increase certainty in survey trawl biomass estimates. Availability of Pacific cod to a survey trawl is one component to understanding its catchability. In an effort to ascertain the percentage of Pacific cod available to bottom trawl surveys, Dan Nichol examined the proximity of Pacific cod to the seafloor using archival tags and independent pooled data from research trawls and determined that approximately 50% of Pacific cod would be available to the EBS trawl, and 90% would be available to the GAO and AI trawl. The manuscript for this research is currently in internal review at the AFSC.

Abundance surveys are conducted during daytime hours to minimize diel changes in vertical distribution and reduce the variance in our biomass estimates. Current research indicates light intensity at the bottom, even during the daylight hours, can influence pollock vertical distribution. Stan Kotwicki is investigating the effect of light intensity on availability of pollock to the eastern Bering Sea survey trawl. From 2004 to 2006, light intensity measurements were collected synchronically with hydroacoustic pollock measurements. Both data sets were analyzed to determine how light intensity affected the vertical distribution of pollock available to the survey trawl. Knowing the relationship between light levels and the vertical distribution of pollock may help reduce the variability in our survey trawl estimates of abundance.

Correlating trawl catch and acoustic data in the eastern Bering Sea

The charter vessels used for the annual eastern Bering Sea demersal trawl survey have in recent years been equipped with the relatively high-end Simrad ES-60 echosounders, which are capable of collecting acoustic backscatter data of a quality approaching that of scientific echosounders. Because these sounders provide a large amount of inexpensive and continuous backscatter data between trawl stations, it is of interest to determine whether these acoustic data can be used to improve the precision of walleye pollock (*Theragra chalcogramma*) trawl index of abundance estimates by incorporating them with the trawl data. Catch and acoustic backscatter data collected from over 400 stations executed during the 2005 field season were analyzed to estimate the correlation between trawl and acoustic data in various layers above the seafloor. The correlation for pollock was good, and the highest correlation was obtained for the layer between the bottom and the headrope ($R^2 = 0.61$). The pattern of correlation for layers above the headrope was characterized by a monotonic decline with increasing height, indicating a lack of vertical herding response among pollock. There was no correlation ($R^2 = 0.02$) between trawl and acoustic data for Pacific cod (*Gadus macrocephalus*), the only other significant fish

source of acoustic backscatter. The discussion is focused on the potential reasons for the discrepancy in the strength of the trawl-acoustic relationship between pollock and cod as well as the factors that may adversely affect the correlation between trawl and acoustic data in general.

Physical and environmental effects on trawl performance

Maintaining a time series as a representative measure of relative abundance for groundfish requires that the performance of the survey trawl is consistent. Various physical and environmental variables can affect trawl performance and add bias or variability to survey data. Ken Weinberg and Stan Kotwicki are investigating performance of the EBS survey trawl using a General Additive Model (GAM). They are analyzing two years of eastern Bering Sea trawl survey haul data to determine what physical and environmental factors effect trawl performance. Trawl performance measures include door and net spread, net height, and bottom contact.

Working Group for Bottom Trawl Survey Improvements (WGBTSI) - Reducing Error in Area Swept Estimates

In January 2006, the Groundfish Assessment Program (GAP) formed a Working Group for Bottom Trawl Survey Improvements (WGBTSI) to assess the GAP survey methodology in the context of the best available science. The primary goal of the WGBTSI is to critically review GAP bottom trawl surveys and to make recommendations for reducing systematic errors in survey procedures and data analyses. From January to March 2007, the group focused on reviewing the components of the area swept calculation used for estimating catch per unit effort (CPUE). The objective is to find the most unbiased estimator for distance fished and net width by modeling the bias caused by noisy or curved data, and the effect of the changing catching efficiency of the trawl during the retrieval period. Model simulations showed that a cubic spline method for estimation of net width and distance fished introduced the least amount of error. For outlier rejection, the group is investigating the use of a more objective and robust method using sequential rejection. Before implementation into GAP data analyses, the WGBTSI plans to formalize these new techniques by writing a manuscript and submitting it for peer review.

ICES participation

For several years, Ken Weinberg has been a delegate for ICES Study Group on Survey Trawl Standardization and a member of ICES Working Group on Fishing Technology and Fish Behavior. Ken is co-convening an ICES Theme Session on "Science Underpinning Stock Abundance Survey Practice (Q)" in Helsinki this September (see flyer).

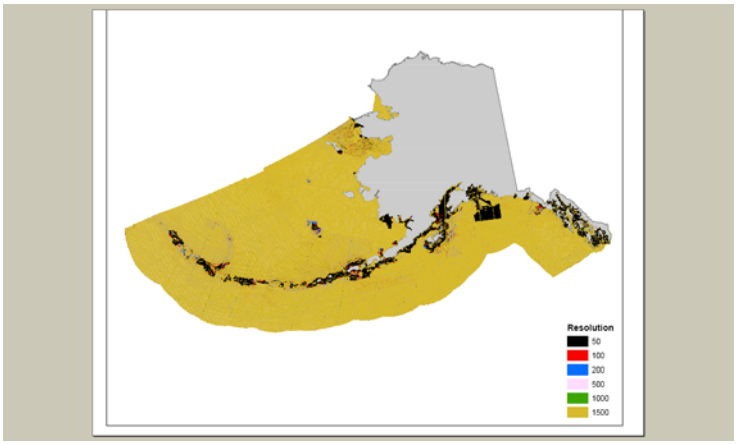
E. Other Items

GIS Resources

With reference to new GIS resources, bathymetric data sources, Steve Lewis at the AK Regional Office compiled GEODAS depth soundings to produce a polygon bathymetry layer for Alaska. From the metadata, the polygons were generated from GEODAS depth sounding data, and are supplemented with polygons from the ETOPO2 data set in regions lacking GEODAS data. The ETOPO2 polygons have horizontal resolutions of 1500 meters, and the GEODAS polygon resolutions vary with original sampling density, from 1000 meters down to 50 meters.

There are four regions with each dataset between 800 meg to 2 gig. Metadata for each area can be read by clicking on the XML metadata file in the table of contents in ArcCatalog, and then on the Metadata tab in the window to the right. A power point file describes the overall

process of how the shapefiles were created. The figure below shows the resolution of the data. Given the size of this data set, please contact Steve.Lewis@noaa.gov directly for access to these data.



For more information, contact Jan Benson (206) 526-4183.

APPENDIX I - Alaska Fisheries Science Center Groundfish-Related Publications and Documents In Press – January 2006 through April 2007

(AFSC authors in bold text)

Alaska Fisheries Science Center (AFSC) Peer-Reviewed Journal Reports and Technical Memoranda in 2006 (AFSC authors are in bold).

Note: Listings of 2006 Groundfish Stock Assessment Reports and AFSC Processed Reports are accessible by following the links provided below to the appropriate AFSC web page.

ABLE, K. W., and **J. T. DUFFY-ANDERSON**.
2006. Impacts of piers on juvenile fishes in the lower Hudson River, p. 428-440. *In* J. S. Levinton and J. R. Walman (editors), The Hudson River estuary. Cambridge University Press, New York, NY.

ABOOKIRE, **A. A.**
2006. Reproductive biology, spawning season, and growth of female rex sole (*Glyptocephalus zachirus*) in the Gulf of Alaska. Fish. Bull., U.S. 104:350-359. Online. (.pdf, 1.12MB).

ABOOKIRE, **A. A.**, and J. F. PIATT.
2006. Oceanographic conditions structure forage fishes into lipid-rich and lipid-poor communities in the lower Cook Inlet, Alaska, USA. Mar. Ecol. Prog. Ser. 287:229-240.

ABOOKIRE, A.A, and **BAILEY, K.M.**
2007. The distribution of life cycle stages of two deep-water pleuronectids, Dover (*Microstomus pacificus*) and rex sole (*Glyptocephalus zachirus*), at the northern extent of their range in the Gulf of Alaska. *J. Sea Res*. 57:198-208.

ABOOKIRE, A., DUFFY-ANDERSON, J.T., and **JUMP, C.M.**
2007. Habitat associations and diet of juvenile Pacific cod, *Gadus macrocephalus* in Chiniak Bay, Alaska. *Mar. Biol.* 150(4): 713-726.

AGOSTINI, V. N., R. C. FRANCIS, **A. B. HOLLOWED**, S. D. PIERCE, **C. WILSON**, and A. N. HENDRIX.
2006. The relationship between Pacific hake (*Merluccius productus*) distribution and poleward subsurface flow in the California Current System. Can. J. Fish. Aquat. Sci. 63: 2648-2659.

BAILEY, K.M., ABOOKIRE A. and **DUFFY-ANDERSON, J.**
In review. Ocean transport paths: a comparison of spawning areas, larval distributions and juvenile nurseries of offshore spawning flatfishes in the Gulf of Alaska.

BORCHERS, D. L., **J. L. LAAKE**, C. SOUTHWELL, and C. G. M. PAXTON.
2006. Accommodating unmodeled heterogeneity in double-observer distance sampling surveys. Biometrics 62:72-378.

BRANCH, T. A., R. HILBORN, **A. C. HAYNIE**, G. FAY, L. FLYNN, J. GRIFFITHS, K. N. MARSHALL, J. K. RANDALL, J. M. SCHEUERELL, E. J. WARD, and M. YOUNG.
2006. Fleet dynamics and fishermen behavior: Lessons for fisheries managers. Can. J. Fish. Aquat. Sci. 63:1647-1668.

BUCHHEISTER, A., **M. T. WILSON**, R. J. FOY, and D. A. BEAUCHAMP.
2006. Seasonal and geographic variation in condition of juvenile walleye pollock in the western Gulf of Alaska. Trans. Am. Fish. Soc. 135:897–907.

BUSBY, **M. S.**, **J. W. ORR**, and **D. M. BLOOD**.
2006. Eggs and late-stage embryos of *Allocareproctus unangas* (family Liparidae) from the Aleutian Islands. Ichthyol. Res. 53:423–426.

BUSBY, **M. S.**, and **R. L. CARTWRIGHT**.
2006. Redescription of *Paraliparis holomelas* Gilbert, 1896 (Teleostei: Liparidae), with a description of early life history stages. Ichthyol. Res.53:369–378.

CARLS, **M. G.**
2006. Nonparametric identification of petrogenic and pyrogenic hydrocarbons in aquatic ecosystems. Environ. Sci. Technol. 40:4233-4239.

CARLS, **M. G.**, **J. W. SHORT**, and J. PAYNE.
2006. Accumulation of polycyclic aromatic hydrocarbons by *Neocalanus* copepods in Port Valdez, Alaska. Mar. Pollut. Bull. 52:1480-1489.

CIANNELLI, L., **BAILEY, K.M.**, CHAN, K.S. and STENSETH, N.C.
2007. Phenological and geographical patterns of walleye pollock spawning in the western Gulf of Alaska. *Can. J. Fish. Aquat. Sci.*

DAVIS, **M. W.**, and **M. L. OTTMAR**.
2006. Wounding and reflex impairment may be predictors for mortality in discarded or escaped fish. Fish. Res. 82:1-6.

DAVIS, **M. W.**, **M. L. SPENCER**, and **M. L. OTTMAR**.
2006. Behavioral responses to food odor in juvenile marine fish: Acuity varies with species and fish length. J. Exp. Mar. Biol. Ecol. 328:1-9.

DAVIS, **M. W.**
2007. Fish bycatch discard and escapee mortality rates can be predicted using reflex impairment. ICES J. Mar. Sci.

De FOREST, L. G., and **M. S. BUSBY**.
2006. Development of larval and early juvenile penpoint gunnel (*Apodichthys flavidus*) (family: Pholidae). Fish. Bull., U.S. 104:476-481. Online. (.pdf, 618KB).

De ROBERTIS, **A.**, and **C. D. WILSON**.
2006. Walleye pollock respond to trawling vessels. ICES J. Mar. Sci. 63:514-522.

DeMASTER, **D. P.**, A. W. TRITES, **P. CLAPHAM**, **S. MIZROCH**, **P. WADE**, R. J. SMALL, and **J. Ver HOEF**.
2006. The sequential megafaunal collapse hypothesis: Testing with existing data. Prog. Oceangr. 68:329-342.

DOUGHERTY, A, B., BAILEY, K. M. and **MIER, K**.
2007. Interannual differences in growth and hatch date distributions of age-0 walleye pollock (*Theragra chalcogramma*) from the Shumagin Islands region of the Gulf of Alaska, 1985 - 2001. *J. Fish. Biol*.

DUFFY-ANDERSON, **J. T.**, **M. S. BUSBY**, **K. L. MIER**, **C. M. DELIYANIDES**, and P. J. STABENO.
2006. Spatial and temporal patterns in summer ichthyoplankton assemblages on the eastern Bering Sea shelf 1996–2000. Fish. Oceanogr. 15:80–94.

EVSEENKO, S. A., **B. LAUREL**, J. A. BROWN, and D. Yu MALIKOVA.
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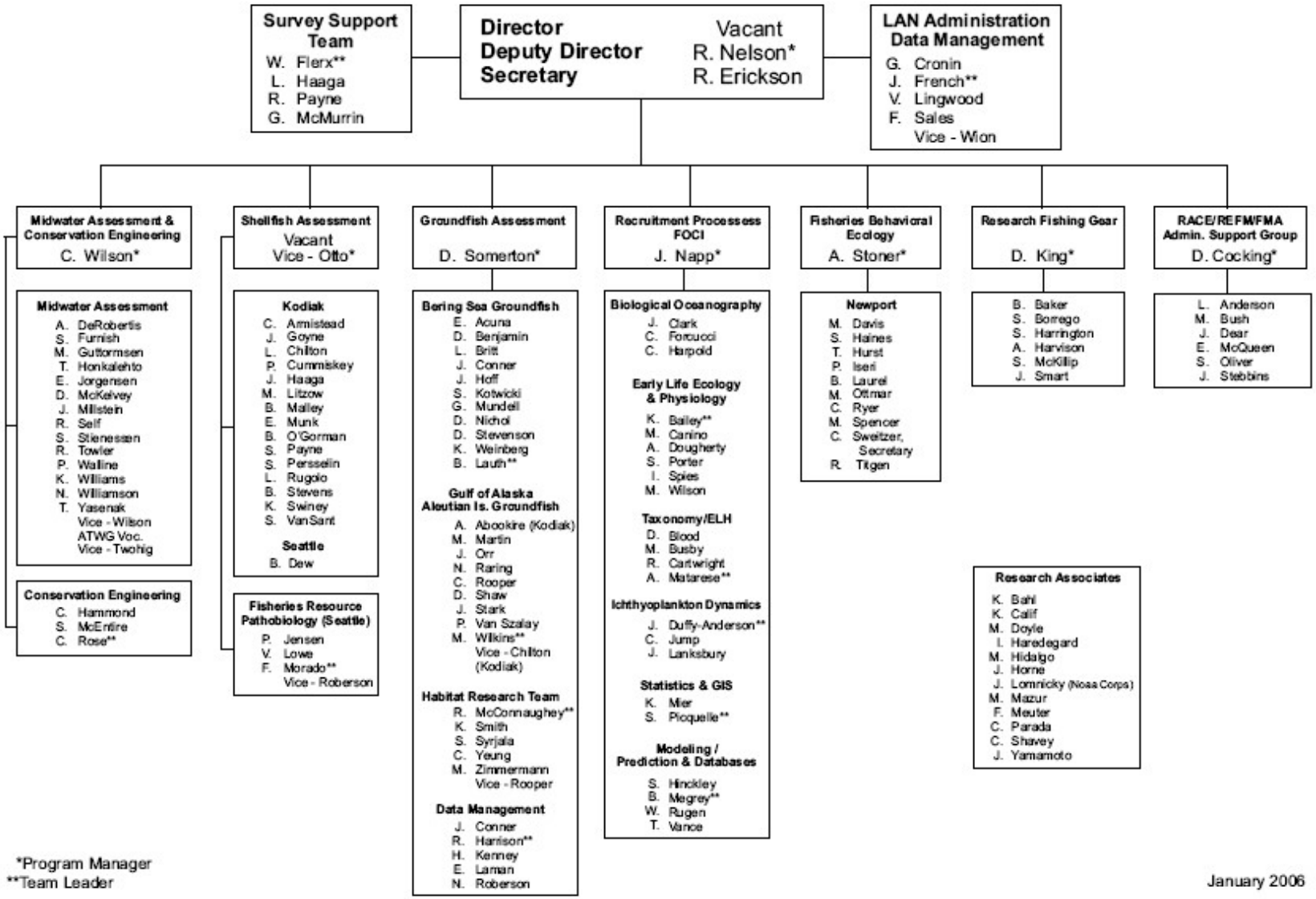
Alaska Fisheries Science Center (AFSC) Groundfish-Related Processed Reports can be listed by year and viewed on the AFSC website at:
http://www.afsc.noaa.gov/Publications/ProcRpts_intro.htm

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION
ORGANIZATION CHART
2006



APPENDIX III.--RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION

Patricia Livingston -- Director
Loh Lee Low -- Deputy Director

Administrative Support

Ito, Daniel -- NEPA coordinator
Goiney, Bernie

Age Determination Unit

Kimura, Dan -- Supervisor
Anderl, Delsa
Benson, Irina
Gburski, Chris
Goetz, Betty
Hutchinson, Charles
Johnston, Chris
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Foy, Dan
Kautzi, Lisa
Shockley, Wes
Short, Jonathan
Piston, Charlses
Brogan, John

Status of Stocks and Multispecies Modeling

Hollowed, Anne -- Supervisor
Conners, Liz
Dorn, Martin
Greig, Angie
Gaichas, Sarah
Ianelli, James
Logerwell, Libby
Lowe, Sandra
Munro, Peter
Pearce, Julie
Spencer, Paul
Thompson, Grant
Turnock, Jack
Stockhousen, Buck
Wilderbuer, Thomas
Neidetcher, Sandi
McDermott, Susanne

Resource Ecology and Ecosystems Modeling

Aydin, Kerim ▪Acting Supervisor
Buckley, Troy
Derrah, Christopher
Lang, Geoffrey
Yang, Mei-Sun

Socio-Economic Assessment

Felthoven, Ron -- Leader
Haynie, Alan
Hiatt, Terry
Lew, Dan
Sepez, Jennifer
Seung, Chang

ADP

Blaisdell, Mark
Wennberg, Sherrie

Revised April 2005

APPENDIX IV - Auke Bay Laboratory Marine Ecology and Stock Assessment (MESA) Program Staff

Name	Duties
Phil Rigby	Program Manager
Doris Alcorn	Seafloor Ecology, Outreach
Dave Clausen	Rockfish, Grenadiers, Alaska Groundfish
Dave Csepp	Forage Fish, Hydroacoustics
Jeff Fujioka	Sablefish, Rockfish, Stock Assessment, Effects of Fishing
Dana Hanselman	Sablefish, Rockfish, Stock Assessment
Jon Heifetz	Effects of Fishing, Rockfish, Sablefish, Stock Assessment
John Karinen	Gulf of Alaska Groundfish
Mitch Lorenz	Essential Fish Habitat
Chris Lunsford	Rockfish, Sablefish, Stock Assessment, Longline Survey
Nancy Maloney	Sablefish Tag Database, Longline Survey, and Seamounts
Cara Rodgveller	Sablefish, Rockfish, Longline Survey, Grenadiers
Tom Rutecki	Sablefish, Webmaster
Kalei Shotwell	Groundfish Habitat, Rockfish, Stock Assessment
Robert Stone	Seafloor Ecology, Effects of Fishing, Coral and Sponge Life History

Other ABL Staff Working on Groundfish

Scott Johnson	Essential Fish Habitat, Forage Fish
John Thedinga	Essential Fish Habitat, Forage Fish
Christine Kondzela	Rockfish Genetics
Sharon Hawkins	Forage Fish Genetics