Alaska Fisheries Science Center
of the
National Marine Fisheries Service

2004 Agency Report
to the
Technical Subcommittee
of the
Canada-US Groundfish Committee

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VIII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT IN 2003

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, 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. A review of pertinent work by these tasks 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 new AFSC Publications Database (searchable). Lists or organization charts of groundfish staff of these three units are included as Appendices II, III, and IV.

RACE DIVISION

In 2003 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 2003 by RACE Groundfish Assessment Program scientists on the eastern Bering Sea

shelf and on the shelf and upper slope of the Gulf of Alaska. Groundfish habitat-related research (previously reported as Trawlex studies) was also continued by RACE scientists under the newly formed Habitat Research Team.

The Midwater Assessment and Conservation Engineering (MACE) Program conducted echo integration-trawl (EIT) surveys of midwater pollock abundance in the Gulf of Alaska during the winter and summer, 2003. Regions included the Shumagin Islands and Sanak Trough in February, Shelikof Strait and areas south and east of Kodiak Island in March, and a feasibility survey in the central/western Gulf of Alaska in June and July.

A distinct highlight of 2003 was the launch of the AFSC's new research vessel, the NOAA ship *Oscar Dyson*, on October 17 in Moss Point, Mississippi. This 209 ft vessel will be one of the quietest research vessels in the world and will be able to conduct hydroacoustic surveys at a speed of 11 knots. It is still being fitted out in Mississippi and will be delivered to its home port of Kodiak in the early fall. Intervessel calibrations are already being planned between the *Dyson* and the *Miller Freeman*.

For more information on overall RACE Division programs, contact Division Director Dr. Gary Stauffer 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 Observer Program and the following tasks: 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. Richard Marasco at (206)526-4172.

AUKE BAY LABORATORY

The Auke Bay Laboratory (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). In recent years, ABL's Groundfish Assessment Program has been primarily involved with research and assessment of sablefish and rockfish in Alaska and with the study of fishing effects on the benthic habitat. In the past three years, the

Groundfish Program has also conducted research to study the interaction between Steller sea lions and prey/predators in Alaska. Presently, the Groundfish Program is staffed by 17 scientists, including 15 permanent employees and 2 term employees. One addition to the program in 2003 was the permanent hiring of Dana Hanselman to work primarily on stock assessment analyses. Dana is completing his Ph.D. from the University of Alaska Fairbanks, Juneau Center for Fisheries and Ocean Sciences, and previously was a National Sea Grant/NMFS Population Dynamics Fellow whose research was cooperative with ABL's Groundfish Program. Four employees in other ABL programs have also been involved with research on groundfish in recent years.

In 2003 field and laboratory research, ABL's Groundfish 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) continuation of a study that used a manned submersible to investigate distribution of deep-water corals in the Aleutian Islands; 2) a multibeam echosounder survey of the Albatross Bank fishing grounds in the central Gulf of Alaska to produce detailed bathymetric and habitat maps for these grounds; 3) scuba diving and laboratory studies to determine the resiliency of sea whips to simulated effects of bottom trawling; 4) a series of cruises in southeast Alaska to test the hypothesis that sea lion prey diversity and seasonality are related to Steller sea lion population trends; 5) ongoing scuba diving studies of growth rates of shallow water coral species to help determine effects of fishing on these taxa in Alaska; 6) continued juvenile sablefish studies, including routine tagging of juveniles and a special sonic tagging study of these fish; 7) 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; 8) electronic archival tagging of Greenland turbot and shortspine thornyhead during the longline survey; 9) a tagging study of Pacific sleeper sharks in southeast Alaska; and 10) continuing habitat studies of groundfish in nearshore and estuarine areas of southeast Alaska.

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 annual status of stocks documents for Alaska groundfish: sablefish, Pacific ocean perch, northern rockfish, shortraker/rougheye rockfish and other slope rockfish, and pelagic shelf rockfish. In 2003, an age-structured model was used for the first time to assess light dusky rockfish, the major species in the pelagic shelf assemblage. Other analytic activities during the past year were: 1) a continuing study of the use of echosounder signals to stratify trawl surveys for Pacific ocean perch and thereby improve survey precision; 2) an analysis of the relative abundance of Pacific sleeper sharks in Alaska based on longline survey data; and 3) development of a relational database for the longline survey to make the survey's data accessible to other researchers and to fishermen. In addition, Groundfish Program staff spent considerable time working on analyses for two Supplemental Environmental Impact Statements (SEIS): a revised Programmatic SEIS for the Bering Sea/Aleutian Islands and Gulf of Alaska Groundfish Fishery Management Plans and a new SEIS for essential fish habitat in Alaska.

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

B. Multispecies Studies

1. Research

Bering Sea Crab/Groundfish Bottom Trawl Survey - RACE

The annual crab-groundfish demersal trawl survey of the eastern Bering Sea shelf was completed from June 2- July 22, 2003. A total of 395 stations were sampled, covering nearly 500,000 km^2 from inner Bristol Bay to the shelf edge and from Unimak Pass to 62° N near St. Matthew Island. The chartered vessels F/V Aldebaran and F/V Arcturus were used for the 11th consecutive year. This also marked the 22nd survey of the 'standard' time series of consistent area, gear, and general sampling protocol.

Preliminary biomass estimates for major species indicated relatively little change from 2002 except for walleye pollock and arrowtooth flounder. Walleye pollock showed a dramatic increase from under 5 million tons in 2002 to 8.5 million tons in 2003. Arrowtooth flounder increased from about 355,000 tons in 2002 to 550,000 tons in 2003. The lack of winter ice cover in the eastern Bering Sea has had an apparent dramatic effect on bottom temperatures. The average bottom temperature for the 2003 survey was 3.81°C, the highest ever seen during the standard time series.

Nineteen additional stations were sampled in inner Bristol Bay and along the Alaska Peninsula to continue our look at improving yellowfin sole biomass estimates. After the standard survey, one vessel was used for gear experiments to estimate the escapement of skate species under the footrope and to find out what effects differing warp lengths between sides has on footrope height. The other vessel was used on the shelf edge and upper slope to investigate combined trawl and hydroacoustic methods on rockfish.

For further information, contact Gary Walters, (206) 526-4143.

Spatial and temporal patterns in Bering Sea invertebrate assemblages

Invertebrate bycatch recorded during the annual RACE Division groundfish trawl surveys in the eastern Bering Sea (1982-2002) was examined to (1) characterize benthic habitats by invertebrate communities, and (2) detect temporal and spatial changes in community structure. These analyses will provide a better understanding of the eastern Bering Sea benthos and may also provide a basis for designing an experimental system to systematically study mobile fishing gear impacts. Consistently in almost every survey, two major groups of stations were found partitioned along either side of the 50 m isobath. Exceptions to this pattern are seen in 1982, 1988, and 1999, when the partition broke down and merged all stations essentially into one homogeneous group (1998 saw a contraction of the coastal cluster). The validity and significance of the possible 'anomalous' pattern is under investigation as is the utility of the two-group pattern for systematic studies of fishing gear effects. Trends and patterns in the biomass and spatial distribution of the invertebrate fauna are also being analyzed in relation to environmental variables and to the abundance and distribution of associated managed species.

For further information please contact Cynthia Yeung, (206) 526-6530.

Gulf of Alaska Biennial Groundfish Bottom Trawl Survey - RACE

The 2003 biennial bottom trawl surveys of Gulf of Alaska (GOA) groundfish resources was conducted from May 20 through August 9. Prior to establishing a biennial schedule in 1999, the RACE Division had surveyed GOA groundfish resources triennially since 1984, with preliminary work in 1978 and 1981. The earlier surveys covered waters out to 500 m depth, but extended deeper only in 1984 (to 825 m) and 1987 (to 750 m). Since 1999, GOA triennial surveys have been designed to cover the continental shelf and slope between 170°W long. and Dixon Entrance out to the 1,000 m depth contour. While the 1999 survey succeeded in sampling the entire area, the 2001 survey area was reduced due to the Division's increased survey responsibility in other areas under limited funding. The 2001 survey area did not include the area east of 147°W long., nor did it extend deeper than 500 m. The 2003 survey covered the entire geographic extent, but the outermost depth stratum (700-1,000 m) was omitted because vessels were unable to fish that deep (insufficient wire length).

Sampling was conducted aboard three chartered commercial trawlers (*Sea Storm*, *Gladiator*, and *Northwest Explorer*), progressing E to W on the shelf and slope to the U.S.-Canada border in SE Alaska. Of the 880 attempted standard survey tows, 809 were successfully completed, ranging in depth from 13 m to 667 m. The primary objective of the biennial groundfish surveys is to build a standardized time series of data to assess, describe, and monitor the distribution, abundance, and biological condition of various GOA groundfish stocks.

When looking at changes since the last survey in 2001, we can only compare abundance estimates in the central and western subareas (W of 147°W long.) shallower than 500 m. In that area, the most abundant species in 2003 were, in order, arrowtooth flounder, Pacific halibut, walleye pollock, Pacific ocean perch, Pacific cod, and flathead sole. Since 2001, the estimated abundance of all of these species except Pacific ocean perch increased: arrowtooth flounder by 87% to 2,540,000 t, halibut by 50% to 518,000 t, pollock by 84% to 387,000 t, cod by 10% to 283,000 t, flathead sole by 56% to 239,000 t. The abundance estimate of Pacific ocean perch declined by 47% to 356,000.

We can compare abundance estimates from the entire survey area between 2003 and 1999 except for species that occur commonly in the deepest stratum (700-1,000 m), such as grenadier. Over the entire GOA survey area, arrowtooth flounder was by far the most abundant species with a total biomass estimate of over 2.8 million t, a 124% increase over the 1999 estimate. Nearly 78% of its biomass was from the central GOA survey subarea. The second most abundant species was Pacific halibut with a biomass estimate of 634,000 t, an 8% increase since the 1999 survey, with 66% of its biomass coming from the central subarea. POP ranked third in abundance at 457,000 t, down 37% from 1999 with 62% of its biomass occurring in the central GOA. Pollock ranked fourth in abundance at 425,000 t, a 33% decrease since 1999, with 50% and 41% of its biomass coming from the western and central GOA, respectively.

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

Recruitment Processes

The mission of the Recruitment Processes Program of AFSC's RACE Division is to understand how environmental variability affects the recruitment success of Alaska's living marine resources. Understanding these processes will lead to better prediction tools and more

accurate predictions of recruitment. Most of the research is based on the paradigm that variability in recruitment to harvestable stocks is set early in the animals life (first year) and is the result of processes strongly influenced by the physical and biological environment in which the early life history stages occur. Within the program are multiple research projects under programs sponsored by the NOAA Fisheries-Oceanography Coordinated Investigations (FOCI), the NOAA Steller Sea Lion Research Program (SSLRP), the North Pacific Research Board (NPRB) and NOAA (Coastal Ocean Program) Global Ocean Ecosystem Dynamics (GLOBEC). FOCI and GLOBEC are collaborative research projects between two NOAA Line Offices: NMFS and Oceans and Atmospheric Research (OAR). OAR's representatives are physical oceanographers and atmospheric scientists from the Pacific Marine Environmental Laboratory. One objective of these coordinated investigations is to improve the timeliness information used by management for decisions on optimal harvest levels, by providing recruitment forecasts during the first year of each new year-class.

FOCI's principal focus has been recruitment processes of walleye pollock. In recent years, however, the group has expanded its research to the early life histories of arrowtooth flounder, cod, Alaska plaice, forage fish (age-0 pollock, capelin, eulachon, Pacific sand lance), and larval transport mechanisms of offshore spawning flatfish (arrowtooth flounder and halibut). New research was begun to use molecular tools to identify and examine genetic diversity within populations pollock, cod, and rays. Archived list of 2003 cruises and cruise reports can be obtained electronically (http://www.pmel.noaa.gov/foci/operations/2003/fieldops03.html). Lists of publications and reports can be viewed either from the AFSC publications web page (http://www.afsc.noaa.gov/Publications/publications.htm) or the FOCI web page (http://www.pmel.noaa.gov/foci/focipubn.shtml).

In 2004 the Recruitment Processes Program and their partners at PMEL will begin a new program, Climate Regimes and Ecosystem Productivity. This program will allow them to shift from a single-species focus to a more formal ecosystem perspective to help meet NOAA's challenge for ecosystem-based management.

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

Fisheries Behavioral Ecology Program - RACE

The Fisheries Behavioral Ecology Program 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 2003 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 the 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. In studies related to discards, an

attempt has been made to understand the key principles which control mortality, integrating analysis of behavioral and physiological assays along with observed mortality. Recent work with sablefish and Pacific halibut have shown that 1) capture and environmental stressors interact to magnify behavior impairment and morality; 2) susceptibility to stress and mortality is species specific and strongly influenced by fish size; and 3) mortality may be delayed, such that it is difficult to estimate through traditional approaches which capture and hold fish aboard vessels or in net pens in the field. The presence of higher levels of mortality in smaller fish indicates that the practice of highgrading in fisheries is counter productive for stocks and should be restricted. Obvious behavior impairment was observed even in fish that were exposed to minimal stressor intensity. Recovery of behavior to control levels occurred within 24 h. The magnitude of behavior impairment was correlated with stressor intensity and was a good predictor of delayed mortality in fish that had sustained physical injury from capture. Discarded fish have behavior impairment that makes them more susceptible to predation after release and this is probably an additional source of delayed morality that is not presently being measured in field studies. The correlations between injury from fishing gear, environmental factors, behavior impairment, immuno-suppression and delayed mortality are presently being investigated in greater detail.

Performance of fishing gear

Capture of fish with baited fishing gear (e.g., longlines and traps) for both prosecution of a fishery and stock assessment depends upon feeding motivation, movement patterns, and sensory capabilities in the target species as well as the design of hooks and other gear. In 2003, the Fisheries Behavioral Ecology Program completed experiments to determine how changing environmental variables influence responsiveness of Pacific halibut and sablefish to baits. Halibut were tested under varying conditions of fish density in large laboratory tanks, and it is now clear that capture rates of halibut will be density-dependent in a non-linear function because of social facilitation in feeding motivation. Sablefish were tested under varying conditions of water temperature (2-8°C) and food deprivation. Responsiveness to bait was strongly effected by both variables with temperature having the largest effect. Reduced sensitivity to olfactory cues, lower swim speed, lower attack frequency, and increased time to attack baits combine to reduce sablefish catchability. Experiments are currently underway to test the effects of temperature on responsiveness to baits in halibut. Population sizes based upon baited gear surveys can be greatly underestimated in conditions where environmental variables such as light, temperature, and fish density reduce feeding motivation and/or locomotion.

Efficiency of trawl gear relies upon fish herding in response to the approaching gear. In flatfish trawls the sweeps stimulate fish to move inward towards the mouth of the trawl, where they subsequently tire and fall back into the meshes. However, this herding response may rely upon fish being able to see and respond to the approaching gear. Northern rock sole, Pacific halibut and English sole were examined in a 35 ft long flume tank to determine how ambient illumination influences their behavioral response to the benthic disturbance associated with the approach of a sweep or footrope. Infrared illuminators and video cameras allowed for behavioral observations on fish reactions as a simulated sweep/footrope approached them. Preliminary analysis for the experiment shows that under conditions where fish can see the approaching gear, they lift off the bottom in advance of the sweep and initiate herding behavior. In darkness, the fish are more often struck by the gear, and when they did respond, typically rose into the water column, letting the gear pass beneath them. This suggests that the sweeps on bottom trawls may

be relatively ineffective at stimulating herding behavior in flatfish at night or at great depth, influencing catch rates.

Habitat studies

During 2003, analysis was completed for field trials in Oregon and Alaska designed to test the efficacy of a towed camera sled compared with diver surveys and fine-meshed survey trawls for quantification of density and habitat associations of juvenile flatfishes and other demersal species. The analyses indicate that the towed camera yielded significantly higher counts for age-0 flatfishes than the trawls, and density estimates equal to or better than diver surveys. The camera sled can be used to cover great distances at relatively low cost and provides a permanent record for surveying both fishes and habitat features.

Given success with the camera sled, surveys for juvenile flatfishes were conducted in three flatfish nursery locations near Kodiak Island in 2003. Intensive surveys were conducted in the center of the nurseries for spatially-explicit interpretation of distribution patterns, while more extensive surveys were employed for analysis of broad-scale habitat associations. Video data on fish abundance and surface features of the habitat are being combined with grab samples to quantify characteristics of the sediment and geographic information systems for spatial analysis. This field study will continue into 2005; however, it is already apparent that soft bottom habitat is not uniform and juvenile flatfishes are not distributed randomly.

Experimental laboratory studies conducted during 2002-03 showed that preferences by juvenile Alaskan flatfishes for benthic habitats with emergent structure can be their reduced vulnerability to predation in such habitats. During 2003, a field experiment was conducted to test responses by flatfishes to habitat complexity in a flatfish nursery ground. This was done by enhancing tracts of bare sand seafloor near Kodiak with shell. Age-0 yr northern rock sole exhibited an unexpected decrease in abundance compared with adjacent unaltered tracts. In contrast, larger (age-2+ yr) rock sole were more abundant in the shell tracts. This raised the possibility that age-0 fish were avoiding the shell because of the presence of larger, potentially threatening flatfish. Subsequent laboratory studies confirmed that larger age-1 rock sole demonstrated a much stronger preference for emergent structure, i.e. shell, than did age-0 rock sole. Furthermore, age-0 rock sole were shown to actively avoid a variety of large flatfish, including age-1 rock sole, age-1 halibut and age-4+ starry flounder. This combination of field and laboratory experiments demonstrated two important considerations relative to fish habitat preference and definition of essential fish habitat. First, preferences for different types of habitat change with fish size or age. Second, a holistic understanding of habitat requires knowledge not only of fish response to structural components of habitat, but also relative to biotic components, such as the abundance of potential predators.

Growth and behavior of flatfishes

Seawater temperature can have a profound impact on fish growth, energy allocation, and behavior, all of which can affect variation in recruitment to a fishery. During 2003, an experiment was completed on the compensatory growth response of halibut to a thermally induced growth reduction. It was demonstrated that increased growth rate was accomplished through reduction lipid energy storage. Reductions in metabolic costs did not contribute to rapid growth as growth-compensating fish were more active than controls suggesting a possible trade-off between rapid growth and predation risk. In another experiment the relationships between feeding behavior and digestive physiology were examined in juvenile halibut at 2, 6 and 10°C. The time required for halibut to locate and consume a meal decreased from several days

at 2° to less than 1 minute at 10°C. Unexpected interactions between temperature and food-deprivation period suggested an energy-conserving behavioral response to starvation. An experiment examining the growth and energy storage rates of young-of-the-year rock sole across a range of temperatures was also completed in 2003. Maximum observed growth rates increased from 0.14% in weight per day at 2° to over 1% per day at 13°.

A series of experiments was designed to examine diel activity patterns in northern rock sole at different temperatures. During the day, fish were active exclusively on the sediment surface, whereas at night, fish frequently swam in the water column or at the water surface. At high temperatures, most of the activity occurred during the daytime. At low temperatures, daytime activity was reduced such that night became the dominant activity period.

Two Oregon State U. graduate students were added to the Fisheries Behavioral Ecology Program in 2003, Megan Petrie and Jena Lemke.

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

Age and Growth Task - REFM

The Age and Growth Program of the REFM Division serves as the AFSC's ageing unit for groundfish species. The program consists of a biometrician, age validation researcher, data manager/technician, and 11 age readers. Ages are usually determined from otoliths, but scales, finrays and vertebrae are sometimes used.

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 whiting, Pacific cod, sablefish, Pacific ocean perch, northern and dusky rockfishes, Atka mackerel, yellowfin sole, rock sole, rex sole, and misc. sole and rockfish species.

Research in the Age and Growth Program in 2003 has focused on the following areas:

1. Craig Kastelle is currently working on the radiometric age validation of walleye pollock break and burn ageing methods.
2. Charles Hutchinson is working on his Masters Thesis which is focused on determining shortraker rockfish ageing criteria by comparing ring counts with radiometric ages. This has proved to be very difficult because the transition zone commonly used to age many species of rockfish has proved very difficult to identify. The bomb carbon age validation of canary rockfish which was performed in collaboration with Jennifer Menkel, Kevin Piner and John Wallace of the NWFSC has been more straightforward.
3. Jake Gregg (a UW contract employee) in collaboration with Delsa Anderl has worked diligently on the ageing of Greenland turbot. They have made considerable progress based on the method of sectioning and staining otoliths.
4. Chris Gburski has taken on the task of ageing skates (big skate, longnose skate, Aleutian skate and Bering skate) using vertebrae. He has traveled to Moss Landing Marine Lab, to consult with Drs. Dave Ebert and Wade Smith and adopt some of their very successful skate ageing methods.

The Age and Growth Program recently hired Dan Foy who comes to us through the University of South Carolina, with a B.S. degree in Marine Science.

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

Resource Ecology and Ecosystem Modeling - REFM

Multispecies, foodweb, and ecosystem modeling and research is ongoing. Documents, symposia and workshop presentations, and a detailed program overview are available on the World Wide Web. These can be viewed from the AFSC web site at: http://www.afsc.noaa.gov/refm/reem/default.htm.

Groundfish stomach sample collection and analysis

The Resource Ecology and Ecosystem Modeling Task 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 2003, we collected samples during bottom trawl surveys of the Gulf of Alaska and the eastern Bering Sea shelves. Observers also collected stomach samples during fishery operations from the eastern Bering Sea. In total, 6,883 stomachs were collected from the eastern Bering Sea and 4,238 from the Gulf of Alaska. Laboratory analysis was conducted on 10,469 fish stomachs from the Bering Sea, and 5,420 from the Gulf of Alaska and Aleutian Islands.

Food habits of the important groundfishes in the Aleutian Islands in 1994 and 1997

The stomach contents of 31 species of groundfish were examined from the Aleutian Islands region. Predation on commercially important fish, crab, and shrimp was common. Atka mackerel were the dominant prey fish and were consumed by Pacific cod, arrowtooth flounder, Pacific halibut, Greenland turbot, Alaska skate, whiteblotched skate, great sculpin, and big mouth sculpin. Pollock was another important prey and was consumed mainly by Pacific cod, arrowtooth flounder, Pacific halibut, Alaska skate, and whiteblotched skate. Pollock cannibalism was not found in this study. Myctophids were also an important prey for arrowtooth flounder, Greenland turbot, Pacific ocean perch, pollock, giant grenadier, shortraker rockfish, and rougheye rockfish. Other forage fish such as Pacific herring, osmerids, and Pacific sand lance were consumed by Pacific cod, arrowtooth flounder, and Pacific halibut. However, each of these species comprised no more than 5% of the stomach contents weight for any predator. Some mesopelagic fish, like bathylagids and viperfish, were found in groundfish stomachs. Tanner crabs were mainly consumed by Pacific cod, Pacific halibut, and great sculpin, but were also eaten by Alaska skate and flathead sole. Pandalid shrimp (which includes all the Pandalus and Pandalopsis species) were important prey of Pacific cod, arrowtooth flounder, shortspine thornyhead, rougheye rockfish, shortraker rockfish, Bering skate, darkfin sculpin, and Aleutian skate.

More information on the diet of the 31 groundfish species examined can be found in Yang (2003). This report includes detailed diet composition data, variation in the diet with predator size, geographic distribution of major prey types, and the size composition of important prey. When applicable, diets of certain species from 1994 and 1997 were compared with those from 1991.

Feeding habits of demersal fish in the Aleutian Islands - evidence of biophysical boundaries

Longitudinal gradients in the feeding habits of Pacific cod, Atka mackerel, pollock and Pacific ocean perch (POP) were assessed from stomach samples collected from 1982 through 1999. A total of 20,985 stomachs were divided among areas of two-degrees of longitude, from 164° W to 170° E. Sample sizes per predator per two-degree block ranged from 11 to 3,588. Diet composition (percent by weight) by two-degree area was calculated for each predator with major prey items presented in detail and minor prey items (about 20% total) combined into "other prey."

The diet composition of all four predators shifted from east to west. East of Samalga Pass the portion of euphausiids consumed ranged from 50-90% while west of the pass it generally made up 10-50% of the diets. Besides a step-decrease in the proportion of euphausiids at Samalga Pass, there was a declining trend in the diets of POP and Atka mackerel from Samalga Pass to the western Aleutians. Copepods and myctophids contributed most to the remaining portion of the diets to the west for POP, Atka mackerel and pollock, and "other prey" increased in a step fashion toward the west for Atka mackerel and pollock. Pacific cod, east of Samalga Pass, consumed mostly pollock, whereas west of the pass, Atka mackerel became an increasingly abundant component. Squid and other fish contribute <20% to the Pacific cod diet east of Samalga Pass, but are very important west of the pass.

In addition to the shift in diet composition at Samalga Pass, there seemed to be changes in diet occurring further west. The gradients were not necessarily unidirectional, which suggests the presence of another biophysical boundary in the western Aleutians. For example, in the diet of POP, the proportion of myctophids increased substantially west of Buldir Island. Similarly, west of Buldir Island, pollock and Atka mackerel diets increased in shrimp, amphipods and polychaetes (included in "other prey"), and the Pacific cod diet increased in shrimp, west of Buldir Island.

While there is no oceanographic data to confirm this, these changes in diet composition throughout the Aleutians can be viewed as biological evidence of biophysical processes yet to be described in this region.

Seabird fishery interaction research

The AFSC is increasing its emphasis on researching seabird-fishery interactions, and incorporating seabirds into ecosystems models being developed for the Bering Sea and Gulf of Alaska. This increased emphasis is partially in response to several national efforts by NOAA Fisheries to focus more effort on minimizing bycatch through fishing gear improvements, standardized reporting, and education and outreach. These strategies are more fully outlined in the recently published National Bycatch Strategy (http://www.nmfs.noaa.gov/bycatch_images/FINALstrategy.pdf), and more specifically, on seabird bycatch, as noted by the National Plan of Action to reduce seabird bycatch in longline fisheries (http://www.fakr.noaa.gov/protectedresources/seabirds/npoa/npoa.pdf). This national focus coincides with work that the AFSC has already been engaged in to characterize all components of seabird mortality from commercial fishing operations, and work collaboratively with the fishing industry and the U.S. Fish and Wildlife Service to reduce or eliminate seabird bycatch. This latter issue is being driven by the overlap between distribution of the endangered short-tailed albatross and commercial fishery operations. There have been several mortalities of these endangered seabirds from longline fisheries, and much collaborative work has been completed to date (see Alaska Region webpage

http://www.fakr.noaa.gov/protectedresources/seabirds.html). Current priorities include continued work to reduce longline seabird bycatch, investigating the incidence of seabird interactions with trawl third wires, developing options for monitoring halibut fleet seabird bycatch, and developing reporting procedures to ensure the public has access to seabird bycatch rates and the results of various studies being conducted.

Ecosystem considerations in fishery management

The Ecosystem Considerations Section for 2004 was completed as part of the Stock Assessment and Fishery Evaluation (SAFE) Reports which are provided to the North Pacific Fishery Management Council (NPFMC). The final document is available on the AFSC web site at: http://www.afsc.noaa.gov/refm/stocks/assessments.htm. The purpose of the Ecosystem Considerations Chapter is to provide scientists and fishery managers with information on the status and trends of various ecosystem components and to evaluate the effects of climate and fishing on the ecosystem. The use of aggregate indicators, which bring together time series data on climate, fishing and biology, is an important part of the chapter but is still in early stages of development.

New to the Ecosystem Considerations section this year is the addition of status and trend information pertaining to salmon, herring, crabs, and zooplankton. Also new to the chapter is the addition of several community indicators, such as community size spectrum and k-dominance curves, indices of biodiversity, recruitment, and survival. Data gaps still include lower trophic levels, such as phytoplankton, additional zooplankton, and nutrient information.

Stock assessment scientists continued to use indicators from the Ecosystem Considerations section to assess ecosystem factors such as climate, predators, prey, and habitat that might affect a particular stock. Also, information regarding a particular fishery's catch, bycatch and temporal/spatial distribution was used to consider the possible impacts of that fishery on the ecosystem. We are still in early stages of using this type of information in stock assessments. However, we anticipate the information could be used to modify allowable biological catch recommendations or spatial distribution of the catch due to ecosystem concerns, or to target further research that would be needed to quantify ecosystem impacts.

Another new addition to the Ecosystem Considerations section is the Ecosystem Assessment. The strategy used, which is modeled after the framework used for ecosystem impact assessment in the draft Programmatic Groundfish Fisheries EIS (PSEIS), provides a systematic way of evaluating ecosystem effects of fishing with respect to predator/prey relationships, ecosystem energy flow, and various measures of diversity. This strategy is intended to complete the intent of the Ecosystem Considerations section that has become a regular accompaniment to the NPFMC's Stock Assessment and Fishery Evaluation (SAFE) documents. While the Ecosystem Considerations section provides historical status and trend information for a variety of ecosystem components, the Ecosystem Assessment is intended to provide advice on possible future trends in the ecosystem, using TAC scenarios of the annual TAC-setting Environmental Assessment. This ecosystem assessment will allow us to fulfill TAC EA requirements to annually assess environmental consequences of TACs on the ecosystem. It also helps meet the guidelines of National Standard 2 - Scientific information in the Magnuson-Stevens Act, that specify that the SAFE report should contain information on past, present, and possible future condition of the stocks, marine ecosystems, and fisheries being managed. Lastly, the assessment will provide guidance on possible aggregate effects of fishing that are not captured under single species assessments.

Multispecies and ecosystem models are proposed as tools to provide advice on possible future trends in various ecosystem indicators. Three models are envisioned for future use in this assessment. The first is a multispecies bycatch model employed in the PSEIS, which employs single-species population projections for groundfish targets along with prohibited species bycatch and optimal yield constraints presently operating in the BSAI and GOA groundfish fisheries to provide realistic future fishing trajectories on target species and indicators of the types and amounts of bycatch. Multispecies virtual population analysis and forecasting models provide an age-structured predator/prey assessment on target groundfish species and ecosystem mass balance and biomass dynamics models provide a more holistic view of possible future trends in ecosystem components. Finally, climate is an important aspect of our prediction of the future state of ecosystems. Work is ongoing among NOAA components to develop more real-time assessment of changing climate states and responses of organisms to those changes. These are incorporated into our ecosystem considerations section of the SAFE and will require discussion about how to incorporate climate into our assessment of possible future climate effects on North Pacific ecosystems.

Arctic climate impact assessment

Two center scientists, Pat Livingston (REEM) and Tom Wilderbuer (SSMA) are contributors to an international effort to assess the effects of climate change on the arctic. The Arctic Climate Impact Assessment (ACIA) (http://www.acia.uaf.edu) is an international project of the Arctic Council and the International Arctic Science Committee (IASC), to evaluate and synthesize knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences. The aim is to provide useful and reliable information to the governments, organizations and peoples of the Arctic on policy options to meet such changes. The National Science Foundation and NOAA are providing funding for the ACIA Secretariat, which is located at the International Arctic Research Center at the University of Alaska Fairbanks. Pat Livingston is a contributor to the assessment on Marine Systems and Tom Wilderbuer is contributing to the chapter on Fisheries and Aquaculture, with contributions focusing on climate change in the Bering Sea. A workshop was held this spring to bring chapter authors together and to provide a means for synthesizing results from the assessment. The peer-reviewed scientific volume will be completed in 2004.

Ecosystem modeling coordination

Kerim Aydin chaired a week long workshop held for the purposes of coordinating data methodologies for constructing quantitative marine food webs and for evaluating the resulting indicators of trophic flow in an ecosystem context. Participants focused on improving the design of current models of the eastern Bering Sea, the Gulf of Alaska, the Aleutian Islands and the Northern California Current. During this meeting, fish, marine mammal, and plankton data were compared between modeled regions, issues of spatial resolution were resolved, and methods for linking databases were standardized to aid incorporation into the Ecosystem Assessment process on an ongoing basis.

Bering Sea research planning

Pat Livingston and Jeff Napp of the Alaska Fisheries Science Center participated in a 3-day workshop in Seattle as part of a working group that will assist in the development of a Bering Sea research plan. The working group outlined a draft science plan at the 17-19 March 2003 workshop, organized around the central scientific question, "How will climate change

affect the ecosystems of the Bering Sea." The ARCUS website provides more details about the planning process, working group members, and progress in development of the science plan at http://www.arcus.org/bering/.

For more information please contact Pat Livingston at (206)526-4242.

Distribution and Habitat of Groundfish in Nearshore Waters of Southeast Alaska - ABL

Scientists at the Auke Bay Laboratory (ABL) Habitat Program continued to assess the distribution, habitat, and behavior of groundfish in nearshore waters of southeast Alaska. In the final year of a 3-year study, eelgrass meadows were sampled for fish assemblages and mapped with GPS at six sites to establish a baseline of information for long-term assessment of biotic change. Two sampling cruises were conducted in 2003: one in winter using a charter vessel and one in summer using the NOAA vessel *John N. Cobb*. Sampling methods included use of a beach seine to capture fish. A total of 44 seine hauls from all sampling periods yielded 58,902 fish representing 45 species. Commercially important species captured included flatfish, Pacific cod, rockfish, salmon, and walleye pollock. Forage fish species captured included Pacific herring and Pacific sand lance. Fish were more abundant in eelgrass in summer than in winter. Studies in 2004 will focus on variation in abundance, size, and diversity of fish assemblages that use eelgrass during the day versus the night.

For more information, contact Scott Johnson at 907-789-6063 or John Thedinga 907-789-6025.

Fish Distribution and Habitat in Southeast Alaska Estuaries - ABL

Scientists in the Auke Bay Laboratory (ABL) Groundfish Program are studying groundfish in southeast Alaska estuaries to determine relationships between fish distribution and environmental conditions. Four sampling cruises were conducted in summer 2003 using the NOAA R/V *John N. Cobb* and a chartered vessel. Fish were captured with nets, and estuarine areas were characterized using two common habitat classification systems, the National Ocean Survey Environmental Sensitivity Index and the Province of British Columbia Shore Zone classification system. To date, more than 50 fish species have been identified in estuaries, including 33 species or species complexes identified for Federal management in Fishery Management Plans of the North Pacific Fishery Management Council. Commercially important species captured include a variety of flatfish, Pacific cod, rockfish, salmon, and walleye pollock.

The goal of this work is to find links between fish assemblages and environmental conditions that can be described with a habitat classification system. The product to date is a Geographic Information System (GIS) that integrates existing relational data on geophysical, biotic, and anthropogenic conditions in a spatial framework. Studies in 2004 will focus on linking fish assemblages to existing habitat types in southeast Alaska estuaries and analysis of how those classifications can be improved as predictors of fish distribution.

For more information, contact Mitch Lorenz at 907-789-6035.

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 that may lead to improved groundfish stock assessments; 2) modeling of groundfish stock structure; 3) contribution to a comprehensive report on bycatch, utilization and discards; 4) helped to develop overfishing definitions for the NPFMC, 5) provided analysis of environmental impacts of the pollock and Atka mackerel fisheries on Stellar sea lions, and 6) worked with the NMFS Alaska Region to provide a supplemental environmental impact statement for the setting of TACs.

Research activities spanned a broad range of topics. Field studies initiated by staff members included the continuing development of a demersal rockfish trawl for improved stock assessment and hydroacoustic approaches for rockfish habitat determination. Significant research contributions on: 1) the examination of climatic effects on the recruitment of North Pacific groundfish species, 2) relationship of Bering Sea oceanography to pollock recruitment, 3) modeling the Pacific whiting fishery behavior, 4) analysis of the geographic and genetic variation in Atka mackerel in the Aleutian Islands, and 5) incorporation of predation in the Gulf of Alaska pollock assessment were presented at various symposia. In addition, staff members participated on nationwide NMFS committees for specifying a precautionary approach to fisheries management; used a Leslie depletion model to analyze Atka mackerel fishery CPUE data; investigated restratifying fisheries data along biological lines as opposed to traditional INPFC areas; worked with other fishery labs in developing and implementing a new stock assessment model, and continued the international cooperative analysis of Bering Sea pollock stocks with Russian scientists. Staff members also served on national and international steering committees of GLOBEC and PICES.

For further information, contact Dr. Anne Hollowed (206) 526-4223.

3. Management

North Pacific Groundfish Observer Program - REFM

The North Pacific Groundfish Observer Program 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 2003, no foreign vessels were allowed to catch or process fish in the U.S. EEZ off the coast of Alaska. The Observer Program trained and deployed 701 observers to 325 vessels and 21 shore plants in Alaska. These observers spent 34,371 days collecting data in 2003. The Program 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.

Dr. William Karp was chosen as the new Observer Program director in June, 2003 returning to a job that he knows well. He served as Program leader from 1993 to 1999. Dr. Karp left the Observer Program to take a leadership position within the RACE division of the AFSC. He was replaced by Dr. Dan Ito, who served in the leadership role until December of 2003.

For further information or if you have questions about the North Pacific Groundfish Observer Program please contact Dr. Richard Marasco (206)-526-4172.

C. By species, by agency

1. Pacific Cod

b. Stock Assessment

BERING SEA/ALEUTIANS

The 2003 stock assessment updates the 2002 assessment by incorporating new catch and survey information. The 2003 EBS bottom trawl survey estimated Pacific cod biomass at 606,000 t, down 2% from the 2002 estimate and near the minimum of the 22 year time series (534,000 t). The Aleutian Islands were also surveyed in 2002 resulting in an estimated biomass decrease of 39% from 2000 which is the lowest value of the time series. The stock assessment model estimates of abundance are almost unchanged from the previous assessment. For example, estimated 2004 spawning biomass for the BSAI stock is 435,000 t, down about 1% from last year's F_{ABC} projection for 2004. 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 422,000 t, 0.39 and 0.47, respectively. The point estimates for $F_{40\%}$, and $F_{35\%}$ are substantially higher than the last two years' values due to different fishery selectivity assumptions made since the 2000 assessment. For example, $F_{40\%}$ was 0.35 in the 2003 assessment and 0.30 in the 2002 assessment.

Pacific cod qualify for management under sub-tier "a" of tier 3 because projected biomass for 2004 is about 1% above *the* $B_{40\%}$ reference level. Fishing at an instantaneous rate of 0.39 is projected to result in a 2004 catch of 297,000 t, which is the maximum permissible ABC under Amendment 56. The ABC for 2004 recommended by the authors is 223,000 t based on a

constant catch approach. The 2004 ABC recommendation is the same as the 2002 and 2003 ABC value.

The Plan Team concurs with the authors recommendation to set 2004 ABC at 223,000 t, equal to the 2002 and 2003 ABC and 25% below the maximum permissible level. This ABC corresponds to a fishing mortality rate of 0.29, well-below the value of 0.39 which constitutes the upper limit on F_{ABC} under tier 3a.

Estimated spawning biomass declined substantially from 1988 to 1998, was stable from 1998 to 2001, and then increased from 2001 to 2003. There is concern by the Plan Team that Pacific cod abundance may be overestimated due to the assumed values of survey catchability and natural mortality and their interaction with the estimated parameters for growth and dome-shaped selectivity. Trawl catchability is assumed to equal 1, yet estimated age-3+ biomass is much greater than survey biomass because the model's estimate of trawl survey selectivity is sharply dome-shaped implying that significant amounts of large cod are not available to the shelf trawl survey. There is concern that comparison of the 2002 slope and shelf survey length data may not support this implication, indicating that the dome-shaped selectivity currently estimated for the shelf survey may not be due to large fish residing on the slope at the time of the survey.

The recommended OFL was determined from the tier 3a formula, where fishing at a rate of 0.47 gives a 2004 value of 350,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

In this year's assessment, the assessment authors pointed out that the ABC of BSAI Pacific cod is not allocated by area. Pacific cod is something of an exception in this regard. The same multiplier (1.17) that is currently used to expand the results of the EBS assessment model into BSAI-wide amounts could be used to apportion the Pacific cod ABC between the EBS and AI management areas. If the 2004 ABC is set at 223,000 t, the EBS and AI portions under this approach would be 191,000 t and 32,000 t, respectively. An AI ABC of 32,000 t would be higher than the 2002 AI catch of 30,801 t and thus would not be expected to result in significant new constraints on the existing fishery. However, it would help to constrain future expansion in a precautionary manner until such time as a more rigorous apportionment methodology can be developed. This ABC split may have substantial implications for Pacific cod management and allocation and will be discussed further at next year's September Plan Team meeting before making a recommendation.

GULF OF ALASKA

New to 2003 assessment is an analysis examining changes in fishing patterns for Pacific cod with respect to fishing gear, area, and month for the past five years. For most categories, significant changes were not exhibited. New data were incorporated into this assessment as follows: (a) size composition data from the 2002 and January-September 2003 commercial fisheries; (b) catch data for 2003 including recompiled catch data for 1991-2002; (c) size composition data from the 2003 GOA bottom trawl survey; (d) biomass estimate from the 2003 GOA bottom trawl survey (the 2003 estimate increased 6% from the 2001 estimate); (e) recompiled survey biomass estimates from 1984-2001. This year's base model, using a length-structured Synthesis approach, is identical in structure to all base model assessments used for GOA Pacific cod stock since 1997. Of note was the 29% decrease to the recompiled 1987 trawl survey estimate, resulting in a general decrease in model estimates of stock biomass early in the time series and increased biomass estimates in the recent portion of the time series.

While this stock was managed under Tier 3b in last year's assessment, the increase in absolute current biomass in this year's assessment, places the GOA Pacific cod stock in Tier 3a since the. estimated 2004 spawning stock biomass (103,000 mt, an increase of 17% over the 2003 estimate) is greater than the $B_{40\%}$ value of 88,900 mt. Similar to assessments during 2000-2003, the 2004 ABC was set at 87% of the maximum permissible F_{ABC} to compensate for the large uncertainty surrounding the *M* and *q* model parameters. The team concurred with the author's recommendation to set the 2004 ABC at 62,800 t, corresponding to a fishing mortality rate of 0.29. The OFL fishing mortality under Tier3a was set at 102,000 mt, corresponding to a fishing mortality rate of 0.41. The 2004 ABC is apportioned according to the average biomass distribution in the three most recent surveys; the apportioned ABC values become 22,610 mt Western (36%), 35,800 mt Central (57%), and 4,400 mt Eastern (7%).

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 is comprised of three species (dusky, yellowtail, and widow rockfish) that inhabit waters of the continental shelf of the Gulf of Alaska and that are thought to exhibit midwater, schooling behavior. At certain times, however, some of these fish are caught in bottom trawls. Dusky rockfish is by far the most abundant species in the group, and has been the target of a bottom trawl fishery since the late 1980's. Two varieties of dusky rockfish are seen: an inshore, dark-colored form, and a light-colored variety found offshore. The trawl fishery takes the light variety. Recent taxonomic work indicates these two forms are separate species, and a publication presenting this information is currently in preparation by Jay Orr of the AFSC RACE Division.

A major change occurred in this year's assessment for pelagic shelf rockfish in the Gulf of Alaska, as an age-structured model was used for the first time to determine exploitable biomass and ABC for light dusky rockfish, the predominant species in the assemblage. This model is a modified version of the northern rockfish model and was first developed in preliminary form in 2002. In 2003, substantial refinements were made to the 2002 base model, and all available data through 2003 were incorporated. The model estimate of current exploitable biomass for light dusky rockfish is 50,380 mt, and recommended ABC for 2004 based on an $F_{40\%}$ harvest rate (0.123) is 4,000 mt. Exploitable biomass for the three other species in the assemblage (dark dusky, yellowtail, and widow rockfish) is computed using their average biomass estimates for last three biennial trawl surveys in 1999, 2001, and 2003, which equal a total of 7,020 mt. Applying an F=0.75M rate to this value of exploitable biomass yields a recommended ABC of 470 mt. Therefore, for the pelagic shelf rockfish group as a whole, total exploitable biomass is 57,400 mt, and recommended ABC for 2004 in the Gulf of Alaska is 4,470 mt. This ABC is a decrease of nearly 19% compared to the 2003 value.

For more information, contact Dave Clausen at (907) 789-6049 or Chris Lunsford at (907) 789-6008.

4. Slope Rockfish

a. Research

GULF OF ALASKA

Species Ientification 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. These collections are significant because very little is known about the species identification, distribution, habitat, and genetic structure of YOY rockfish in Alaska. Based on a pilot study of species identification with morphological analysis by Dr. Arthur Kendall (retired from AFSC's RACE Division) and with mitochondrial DNA analysis by ABL scientists in cooperation with Dr. A. J. Gharrett of the University of Alaska Fairbanks, Juneau Center for Fisheries and Ocean Sciences (UAF, JCFOS), the majority of the rockfish are Pacific ocean perch (*S. alutus*; POP). Seven other species were also identified: shortraker, rougheye, dusky, darkblotched, widow, and yellowmouth rockfish.

In 2003, about one-third of the collections were processed for further analysis. Fish were visually separated into POP-type and non-POP-type fish. Tissues from 690 POP-type fish were preserved for genetic analysis. A subset of 152 fish were sampled for future stomach content analysis by Dr. Nicola Hillgruber of the UAF, JCFOS, 198 heads were retained for aging by otolith analysis, and 55 were preserved by Dr. Kendall for morphological analysis. In addition, 73 non-POP-type fish were processed for species identification, and 16 and 15 non-POP-type fish were retained for aging and stomach content analysis, respectively. The size range of all the fish processed was 15–62 mm SL.

Dr. A. J. Gharrett will be taking the lead on determining the extent of POP genetic divergence between year-classes and between geographic locations using microsatellite DNA markers. For the species identification analysis of the non-POP-type fish, ABL scientists in cooperation with UAF will conduct a genetic analysis using mtDNA variation, which Dr. Kendall will supplement with a morphological analysis. This may lead to developing morphological methods for species identification of YOY rockfish. To determine whether the rockfish in these collections are one year-class, i.e. young-of-the-year, the otoliths will be aged by the AFSC REFM Division aging unit in Seattle.

Future examination of the remaining collections would: 1) provide larger spatial and temporal sample sizes for examining POP population genetic structure, and 2) increase the number of non-POP-type fish available for examination and possibly provide a spatial and interannual assessment of species abundance. In addition, new microchemistry techniques of otoliths are available that may augment population structure analyses.

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

Application of Echosounder Signal to Improve Trawl Survey Precision for Pacific Ocean Perch

Auke Bay Laboratory staff have been examining ways to improve trawl survey design for Pacific ocean perch, including methods for efficiently increasing sample size and precision. One way to increase sample size with minimal effort is to collect hydroacoustic signals, both during trawl hauls and between hauls. Further evaluation of this technique to improve rockfish survey precision continued during 2001-2003. Echosounder signals were recorded with a Simrad ES60 echosounder during AFSC RACE Division trawl surveys of the Gulf of Alaska in 2001 and 2003 and of the Aleutian Islands and eastern Bering Sea slope in 2002. The 2001-2002 data have been processed and analyzed. A significant but moderate relationship between hydroacoustic backscatter and catch-per-unit-effort was found. The data were then combined with localized catch composition into a predictive model. This model was used to predict catches in the vicinity of trawl tows as an auxiliary variable. These predictions were used in a double sampling design which showed gains in precision. The hydroacoustic data may have utility in post-stratifying random designs or to stratify future surveys. The results of this work is a chapter in press in a book entitled Sampling Rare or Elusive Populations: Challenges and Choices edited by William Thompson.

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

Juvenile Rockfish Habitat and Energetics in the Aleutian Islands

A pilot study was conducted to examine the feasibility of using echosounder data to delineate and map fish habitats in the eastern Aleutian Islands near the Islands of Four Mountains. These data are being processed with QTC View software to generate data necessary to classify the area into seabed types. At each site a sediment sample was taken using a Shipek grab, and underwater video was collected using a drop camera to ground-truth the acoustic data. A second purpose of the study was to initiate techniques to identify links between habitat forming organisms (primarily sponges and corals), rockfish density, and rockfish condition. Energetic content and zooplankton abundance will be compared among sites and treatments to determine the relative benefit to rockfish growth and condition of one site over another. A full-scale version of this acoustic mapping project linking habitat to juvenile rockfish energetics will commence in summer 2004.

For further information, contact Chris Rooper at (206)526-4689.

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS

Pacific ocean perch (POP)

The present assessment updates last year's assessment, including incorporation of revised 2002 harvest levels, 2002 survey age compositions, and Aleutian Islands fishery length

compositions. No new survey information was available from the Aleutian Islands in 2003. 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 130,000 t, 0.048, and 0.057, respectively. Projected spawning biomass for 2004 is 123,000 t, placing POP in sub-tier "b" of Tier 3. The maximum F_{ABC} value allowed under Tier 3b is computed as follows:

$F_{ABC} = F_{40\%} \times (B_{2004} / B_{40\%} - 0.05)/(1-0.05) = 0.048 \times (123{,}000/130{,}000 - 0.05)/0.95 = 0.045$

Projected harvesting at a fishing mortality rate of 0.045 gives a 2004 ABC of 13,300 t, which is the recommended ABC. ABCs are set regionally based on the 2002 apportionment as follows: BS = 2,128 t, Eastern Aleutians (Area 541) = 3,059 t, Central Aleutians (Area 542) = 2,926 t, Western Aleutians (Area 543) = 5,187 t. The OFL fishing mortality rate is computed under Tier 3b as follows:

$F_{OFL} = F_{35\%} \times (B_{2004} / B_{40\%} - 0.05)/(1-0.05) = 0.057 \times (123{,}000/130{,}000 - 0.05)/0.95 = 0.054$

Projected harvesting at a fishing mortality rate of 0.054 gives a 2004 catch of 15,800 t, which is the authors' and Plan Team's recommended OFL for the BSAI. The OFL for BSAI is not regionally apportioned. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Northern rockfish

Through 2000, the other red rockfish complex was split into northern/sharpchin and rougheye/shortraker groups in the AI, with a combined "other red rockfish" group for the eastern Bering Sea. In 2002, sharpchin rockfish was moved into the other rockfish complex. In 2003, northern rockfish and shortraker/rougheye rockfishes were separated from the complex (which is no longer used).

The assessment author used an age-structured model for BSAI northern rockfish for the first time, using age data from the Aleutian Island trawl survey. Thus, northern rockfish, which had previously been managed under Tier 5, are now managed under Tier 3 due to the availability of reliable estimates for $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (26,900 t, 0.059, and 0.070 respectively). Since the female spawning biomass (43,700 t) is greater than $B_{40\%}$, sub-tier "a" would be applicable. Under Tier 3a, the maximum permissible ABC would be 6,880 t, which is the recommendation for the 2004 ABC. The ABC is apportioned between the EBS and AI, with 6,861 t in the Aleutian Islands and 19 t in the Eastern Bering Sea. Under Tier 3a, the 2004 OFL would be 8,140 t for the Bering Sea/Aleutian Islands combined. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Shortraker/rougheye rockfish

Through 2000, the other red rockfish complex was split into northern/sharpchin and rougheye/shortraker groups in the AI, with a combined "other red rockfish" group for the eastern Bering Sea. In 2002, sharpchin rockfish was moved into the other rockfish complex. In 2003, northern rockfish and shortraker/rougheye rockfishes were separated from the complex (which is no longer used). 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 identifying shortraker and rougheye rockfishes to species. NMFS established separate BS and AI TACs for northern rockfishes and separate BS and AI TACs for the combined shortraker/rougheye rockfishes category. Staff with the NMFS Regional Office and Observer

Program have developed a catch accounting program that will be able to identify shortraker and rougheye rockfishes to species for the first time in 2004. The Plan Team continues to support single species management for this complex and recommends separate shortraker and rougheye OFLs and ABCs for 2004.

The SSC has previously determined that reliable estimates of biomass and natural mortality exist for the stocks in this complex, thereby qualifying shortraker rockfish and rougheye rockfish for management under Tier 5. This year's chapter features an assessment model for the first time. At present, the model's chief benefit is that it provides an improved estimate of biomass. In the future, it is possible that the new model will permit management of these stocks in a higher tier. At the present time, the Plan Team recommended that the SSC retain Tier 5 management for these stocks. The Plan Team recommended setting F_{ABC} at the maximum permissible level under Tier 5, which is 75% of M. Accepted values for M for these stocks are: rougheye rockfish--0.025, shortraker rockfish--0.030. The Plan Team agrees with the authors' recommendations of a combined BSAI 2004 OFL and ABC for shortraker rockfish of 700 t and 526 t and a combined BSAI 2004 OFL and ABC for rougheye rockfish of 259 t and 195 t. The management of these small OFLs will be challenging. These species are not targeted but are harvested incidentally in numerous target fisheries. 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" 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 updated assessment includes catches in the EBS and AI, updated length frequency data and analyses of growth of light dusky rockfish and shortspine thornyheads, and maps and analyses of light dusky rockfish catch in localized areas of the EBS and AI; there are no new survey data for BSAI "Other Rockfish." 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. The authors recommend using Tier 5 criteria to assign separate ABCs and OFLs in the EBS and AI for shortspine thornyheads (using the 5-year survey average for biomass and M=0.07), and using Tier 6 (average catch from 1998-2002) criteria for the remaining species in the "Other Rockfish" complex. While the Plan Team believes that this general approach has promise, the Plan Team did not endorse this method for recommending ABCs and OFLs for BSAI Other Rockfish in 2004 because of the lack of time for review and public comment on the proposal. The Plan Team recommends that the author propose essentially the same method in September 2004 for the 2005 specification process, but with the following changes: the Plan Team recommends that Tier 5 criteria be used to assign separate ABCs in the EBS and AI and a combined BSAI OFL for shortspine thornyhead, and that Tier 6 criteria be used to do the same for the remaining species in the complex; splitting ABCs between areas while assigning a BSAI-wide OFL would be consistent with the management of most other BSAI rockfish species. For 2004 BSAI "Other Rockfish" ABC and OFLs, the Plan Team recommends that the method used last year be retained. The SSC has determined that a reliable estimate of the natural mortality rate exists for this complex, thereby qualifying "other rockfish"

for management under Tier 5. The Plan Team recommends setting F_{ABC} at the maximum value allowable under Tier 5, which is 75% of M (0.07), or 0.053. Multiplying this rate by the best estimate of complex-wide biomass gives a 2004 ABC of 960 t in the EBS and 634 t in the Aleutian Islands.

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

GULF OF ALASKA

Previously, the assessments for all species of slope rockfish in the Gulf of Alaska were presented together in a single report in the annual Stock Assessment and Fishery Evaluation (SAFE) document prepared for the North Pacific Fishery Management Council. However, starting in 2003, it was decided to divide the assessments into three separate reports: Pacific ocean perch, northern rockfish, and shortraker/rougheye and other slope rockfish.

Pacific ocean perch (POP)

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. A preliminary assessment of uncertainty in the 2002 SAFE (Stock Assessment and Fishery Evaluation) document indicated some potential model specification problems. Because of this, models in the 2003 assessment were evaluated using Markov Chain Monte Carlo simulations to estimate posterior distributions of key parameters. The base model from 2002 is contrasted with four alternative models. The assessment methodology of the recommended model is the same, but the model is more stable and many constraints were reduced or eliminated. The key differences are a new length-age transition matrix and a relaxation of the fishing mortality regularity penalty. Substantive changes of input data for the 2003 assessment include: addition of 1998, 1999, and 2002 fishery ages, 2003 survey biomass estimate, removal of the 1978 fishery size data, and revised weight-at-age. Based on improved fits to the data and more realistic posterior distributions, we recommend that the ABC of 13,340 mt from a new model be used for the 2004 fishery. This ABC is similar to the 2003 ABC of 13,660 mt. The results of the model are essentially the same as in the 2002 SAFE report, with the main features in the new assessment being a much better fit to the data, a similar ABC as 2003, and B_{2004} remaining above $B_{40\%}$, with projected biomass decreasing slightly.

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

Northern rockfish

Northern rockfish is the second most abundant rockfish in the Gulf of Alaska. The 2003 northern rockfish assessment used an age-structured model identical to that used in the 2002 assessment. New input data included biomass estimates from the 2003 biennial trawl survey, fishery catch from 2002 and preliminary catch for 2003, age compositions from the 2001 biennial survey and 2002 fishery, and length compositions from the 2003 fishery. Based on the model, the estimated exploitable biomass and recommended 2004 ABC for Gulf of Alaska northern rockfish in 2004 are 95,149 mt and 4,870 mt, respectively. The northern rockfish stock

is thought to be decreasing because of recent weak recruitment. Compared with 2003, the 2004 ABC decreased approximately 12%.

For more information contact Dean Courtney at (907) 789-6626.

Shortraker/rougheye and other slope rockfish

As in previous years, the assessments for shortraker/rougheye rockfish and other slope rockfish in the Gulf of Alaska were not based on modeling, but instead relied on biomass estimates provided by trawl surveys. Exploitable biomass for each of these two management groups was estimated by the average biomass in the three most recent biennial trawl surveys, excluding the estimated biomass in the 1-100 m stratum. The 1-100m 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 73,000 mt for shortraker/rougheye rockfish and 89,460 mt for other slope rockfish. Applying a combination of F=M and F=0.75M rates (depending on the species) to these values of exploitable biomass results in recommended ABC's for 2004 of 1,760 mt for shortraker/rougheye rockfish and 3,900 mt for other slope rockfish. The ABC for shortraker/rougheye was subsequently lowered to 1,318 mt at the December 2004 North Pacific Fishery Management Council (NPFMC) meeting to ensure that shortraker rockfish would not be proportionately overharvested within the group.

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

5. Thornyheads

b. Stock Assessment

GULF OF ALASKA

The same stock assessment model was presented this year as in past years for the thornyhead assessment. Seven alternative models were presented in addition to the base model recommended by the authors for the past three years. To explore model behavior, these models fixed natural mortality rates and selectivities, used different assumptions about length at age, and varied the prior assumption about natural mortality. The best fits to the available data were achieved with the model using the highest prior assumption about natural mortality, M=0.10. This natural mortality rate seems excessively high for a species suspected to have very slow growth and long life, but the result is consistent with the tendency from previous years for the model to estimate relatively high natural mortality rates. The model as currently configured seems unable to reconcile assumptions about length at age and longevity particularly given the small number of length samples from the longline fishery. The problem is ongoing, and is unlikely to be resolved until actual age data is available for use in the model and until length sampling from the longline fishery is improved. The Plan Team supported the use of the model in general but concurred with the authors' opinion that the available data, especially the lack of age information, do not support age structured modeling for this population at this time. The minimal information necessary for future use of an age-structured model for estimating ABC and

OFL are: age composition from GOA trawl surveys, age composition from sablefish longline surveys, and improved length sampling from longline and trawl fisheries.

An alternative method for setting ABC and OFL under Tier 5 was introduced this year in response to continued discomfort with the model estimates of natural mortality and other parameters. The average of the two most recent complete GOA trawl survey biomass estimates (1999 and 2003) was used as an estimate of exploitable biomass of 86,200 mt. The ABC was determined by multiplying the exploitable biomass by M=0.03 and 0.75 giving 1,940 mt**.** The corresponding OFL recommendation results in 2,590 mt. The OFL fishing mortality rate under Tier 5 is set equal to the estimate of M, soF_{OFL}=0.03. Area apportionments for thornyhead ABC's in 2004.

Western	Central	Eastern	Total
407	1,009	524	1,940

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

6. Sablefish

a. Research

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

Sablefish Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987-2003. 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 2003, the twenty-fifth annual longline survey of the upper continental slope of the Gulf of Alaska was conducted, along with a similar survey of the eastern Bering Sea. One hundred-fifty-two longline hauls (sets) were completed between 28 May 2003 and 1 September 2003 by the chartered fishing vessel *Ocean Prowler*. Sixteen kilometers of groundline were set each day, containing 7200 hooks baited with squid.

Sablefish (*Anoplopoma fimbria*) was the most frequently caught species, followed by giant grenadier (*Albatrossia pectoralis*), Pacific cod (*Gadus macrocephalus*), and arrowtooth flounder (*Atheresthes stomias*). A total of 86,617 sablefish was caught during the survey. A total of 4,068 sablefish, 535 shortspine thornyhead (*Sebastolobus alascanus*), and 100 Greenland turbot (*Reinhardtius hippoglossoides*) were tagged and released during the survey. Electronic temperature-depth tags were surgically implanted in forty-five Greenland turbot and fifty-five shortspine thornyheads. This is the first time these species have been tagged with electronic tags. Length-weight data and otoliths were collected from 2,045 sablefish. Killer whales (*Orcinus orca*) took fish from the longline at seven stations in the Bering Sea and three stations in the western Gulf of Alaska. These numbers are slightly higher than previous years. Sperm whales (*Physeter macrocephalus*) were common near the vessel in the eastern Gulf and west Yakutat region and were observed taking fish from the line at several stations, which is similar to previous years.

Several special projects were conducted during the 2003 survey. Corals caught on the line were collected for identification and sample preservation. Several specimens of exceptionally rare black coral (*Antipatharia* sp.) were collected. A seabird occurrence study was conducted for the second year. This study is being conducted during several different surveys and hopes to address where and when certain seabird species occur in Alaska waters. In addition, the Alaska Department of Environmental Conservation (ADEC) is conducting a monitoring project for environmental contaminants in Alaskan fish. Fifty specimens of sablefish caught on the longline survey were collected throughout the Gulf of Alaska and Bering Sea and sent to ADEC for contaminants analysis.

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

Longline Survey Web Accessible Database

Scientists from the AFSC in cooperation with Alaska's longline fishing industry have been conducting an annual longline survey to assess the distribution and abundance of major groundfish species inhabiting the upper continental slope in the Gulf of Alaska, Aleutian Islands and the eastern Bering Sea. This survey is aimed primarily at sablefish, and the time series dates back to 1978. Unfortunately, the availability and access of these data by other researchers and by longline fishermen have been limited. Leaders in Alaska's longline fishery who are active in the North Pacific Fishery Management Council have requested that AFSC scientists working at the Auke Bay Laboratory (ABL) develop a relational database of the historical longline survey data which they could access and conduct inquiries from a web site on the internet.

In 2003, an outside vendor was contracted to develop this database containing the existing survey data. Currently the vendor is working on making the database accessible to researchers and longline fishermen through the development of an interactive website. Detailed information such as relative population numbers and abundance estimates have been developed for only sablefish over the entire time series. We hope to expand these data to include all species caught in the survey over the entire time series, which would be valuable for determining population trends for non-target species and provide a long time series for assessing these species. When completed, the web site will be expanded to include this new information in a user-friendly interface readily available to the public.

For more information, contact Chris Lunsford (907) 789-6008 or Michael Sigler at (907) 789-6037.

ABL Sablefish Tag Recovery Program

Processing tag recoveries and administration of the reward program continued during 2003. Total tags recovered for the year are expected to be around 600, which is about the same as last year. One fish at liberty over 31 years and three fish at liberty over 30 years were recovered in 2003. All four were released and recovered in Chatham Strait

Tagging continued on the 2003 sablefish longline survey, with 4,068 adult sablefish tagged and released. An additional 810 juvenile sablefish were tagged and released in St. John

Baptist Bay, near Sitka. Database sablefish releases now total 318,851, including 285,365 adults and 33,486 juveniles. There are 25,249 recoveries to date.

Sablefish tagging on Gulf of Alaska seamounts was carried out from 1999 to 2002 in an effort to determine whether fish which travel to the seamounts ever return to the slope. To date, 16 fish from six of the eight seamounts sampled have been recovered on the continental slope, proving that emigration does occur. So far, no sablefish has been recovered on a seamount other than the one where it was released.

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

Archival Sablefish Tags

During the 1998, 2000, 2001, and 2002 sablefish longline surveys, a combined total of 596 sablefish were surgically implanted with an electronic archival tag. Two fish were tagged and released at each station from the eastern Aleutian Islands and eastern Bering Sea throughout the Gulf of Alaska to Dixon Entrance. The archival tag contains a computer chip that records depth and temperature for a period of 1-1/2 to 2 years. Data from these tags will provide information about sablefish behavior in the sea as well as the marine environmental conditions they experience. To date, 50 tags have been recovered. Rewards of $200 or $500 are being offered to fishermen for the recovery of these tags, depending on the year of release. Based on the recovered tags, three daily movement patterns have been observed: random movement (irregular depth movements not related to time of day), diel vertical movement (greater depths during day and movement to shallower water at night), and reverse diel vertical movement (shallower depths during day and movement to deeper water at night).

For more information, contact Michael Sigler at (907) 789-6037.

Juvenile Sablefish Studies

Juvenile sablefish studies in Alaska have been conducted by the Auke Bay Laboratory since 1984 and were continued in 2003. A total of 736 juvenile sablefish (age 1+) were tagged and released during a cruise of the NOAA vessel *John N. Cobb* at St. John Baptist Bay near Sitka in September-October 2003. This relatively small bay is the only known location in Alaska where juvenile sablefish have been consistently found. During the same cruise, 74 additional juveniles were implanted with electronic archival tags and released. The archival tags are programmed to record temperature and depth and are designed for recovery in the commercial fishery at age 2+ or greater.

Also during the cruise, a total of 13 electronic, acoustically-transmitting sonic tags was surgically implanted into juvenile, age 1+, sablefish captured in St. John Baptist Bay. The tags were programmed to acoustically transmit a record of temperature and depth experienced by the fish. Mobile acoustic receivers located onboard the *John N. Cobb* were used to monitor short-term juvenile sablefish behavior and habitat utilization in the bay. In addition, fixed acoustic receivers were set in St. John Baptist Bay to determine long-term behavior patterns and the timing and duration of emigration from the bay to the more open waters of the Gulf of Alaska. Analysis of the data from the sonic tags has not yet been completed.

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

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

The 2003 sablefish assessment showed that sablefish abundance increased during the mid-1960's due to strong year classes from the late 1950's and 1960's. Abundance subsequently dropped during the 1970's due to heavy fishing; catches peaked at 56,988 mt in 1972. The population recovered due to exceptional year classes from the late 1970's; spawning abundance peaked again in 1987. The population then decreased as these exceptional year classes died off.

The longline survey abundance index decreased 7% from 2002 to 2003. This decrease follows recent increases, so that relative abundance in 2003 is 10% higher than in 2000. The fishery abundance index also generally increased and is 6% higher in 2002 than in 2000 (2003 fishery data are not yet available). Spawning biomass is projected to decrease slightly (<1%) from 2003 to 2004. Sablefish abundance is moderate; projected 2004 spawning biomass is 40% of unfished biomass. Abundance has increased from a low during 1998 to 2000. The 1997 year class is an important part of the total biomass and is projected to account for 31% of 2004 spawning biomass. Another year class likely is above average, the 1998 year class, although not as strong as the 1997 year class.

We have recommended recent ABC's less than the maximum permissible because sablefish abundance has been low. Abundance now has increased to a moderate level due to conservative quotas in previous years and the strong 1997 year class. The maximum permissible yield from an adjusted $F_{40\%}$ strategy is 25,400 mt for 2004 and 20,700 mt for 2005. This 2004 ABC, however, represents a substantial increase (22%) while abundance is projected to decrease slightly (1%). Furthermore, the probability that the maximum permissible yield will reduce spawning biomass below the benchmark $B_{30\%}$ in five years is 0.27. Thus, we recommend a 2004 ABC less than the maximum permissible, either 23,000 mt or 20,700 mt for the combined Bering Sea, Aleutian Islands, and Gulf of Alaska stock. The 23,000 mt ABC is a moderate increase (10%) compared with the maximum permissible ABC. This ABC increase represents a balance between a stock now at the target abundance but also projected to decline. This ABC increase appears to be sufficiently risk-averse given that next year's assessment will re-evaluate the stock status. The 20,700 mt ABC is similar to the 2003 ABC of 20,900 mt. This ABC is more risk-averse because it is consistent with the abundance trend. Abundance is projected to decline slightly in 2004 and continue decreasing thereafter. A 2004 ABC of 23,000 mt was recommended by the NPFMC Groundfish Plan Teams and Science and Statistical Committee, and this was the 2004 ABC value accepted by the NPFMC at its December 2003 meeting.

For more information, contact Michael Sigler at (907) 789-6037 or Sandra Lowe at (206) 526-4230.

7. Flatfish

a. Research

BERING SEA

Distribution of flathead sole by habitat in the Bering Sea

Biotic and abiotic variables were analyzed to identify preferred habitat for flathead sole in the Bering Sea. A model was constructed based on data from three Bering Sea bottom trawl surveys and then tested on data from two different years. Habitat variables were chosen based on their presumed importance for growth and survival, and included sediment type, temperature, depth, prey biomass, and invertebrate cover. Statistical models were used to describe the relationships between flathead sole catch and each of the five habitat variables.

For further information, contact Chris Rooper at (206)526-4689.

b. Stock assessments

BERING SEA

Yellowfin sole

The 2003 assessment incorporates the 2003 catch and trawl survey information. This year's EBS bottom trawl survey resulted in a biomass estimate of 2,280,000 t, an increase of 14% from last year's survey. As in last year's assessment, the authors investigated the relationship between survey catchability (q) and mean annual bottom water temperature using a linear model. Results indicated that q, averaged over 22 survey years, = 1.35.

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 390,000 t, 0.12, and 0.14, respectively. Given that the projected 2004 spawning biomass of 446,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3. For the 2004 fishing season the F_{ABC} was set at the $F_{40\%}$ (=0.12) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 114,000 t. The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.14 gives a 2004 OFL of 135,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The yellowfin sole stock had been slowing declining over the past twenty years due to average recruitment levels which are less than those which built the stock to high levels in the late 1960s and early 19770s. However, the female spawning stock remains well above the target level (B_{40}). In response to SSC recommendations, the authors analyzed stock-recruitment data to consider an alternative assignment of yellowfin sole harvest policy under Tier 1. The authors fit Ricker stock-recruitment curves to two different time-series of data (1954-1999 and 1978-1999) inside the model and obtained very different estimates of MSY and F_{msy} depending on which time-series was utilized.. Concerns regarding the reliability of the stock-recruitment model fit to these data precluded their use to implement a tier 1 harvest strategy at this time.

Rock sole

Changes to the input data in 2003 assessment include addition of the 2002 fishery age composition, 2002 survey age composition, and 2003 trawl survey biomass point estimate and standard error. This year's bottom trawl survey resulted in a biomass estimate of 2,140,000 t, a 12% increase over last year's estimate of 1,900,000 t. The assessment continued the investigation of catchability (q) began in 2002. Prior to 2002, modeling assumed a catchability (q) of 1.0. Last year's assessment used a catchability (q) of 1.82 based on the fit to all of the population information in the model. Increasing q by this magnitude resulted in estimates of abundance which were approximately half of the previously estimated values. In this year's assessment, a value of 1.4 obtained from a trawl "herding" experiment was used as the mean of a prior distribution on q. The new assessment gives a q estimate of 1.45. This results in estimates of total and female spawning biomass that are higher than last year's estimates but still lower than previous estimates. Biomass of rock sole is expected to decline over the next few years due to below average recruitment observed in the 1990s.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore this stock qualifies for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 203,000 t, 0.17, and 0.21, respectively. Given that the projected 2004 spawning biomass of 425,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3. The recommended F_{ABC} is at the $F_{40\%}$ (=0.17) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 139,000 t.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.21 gives a 2004 OFL of 166,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The authors responded to a request by the SSC to examine rock sole for possible management under Tier 1. In the case of rock sole, the time series of recruitment estimates from this assessment is 28 years. In the stock assessment model, a Ricker form of the stock-recruit relationship was fit to these data. Very different estimates of F_{MSY} and B_{MSY} were obtained depending on which years of data were included. Recent research indicates a decadal scale shift in atmospheric forcing, which may affects the recruitment of rock sole. Given these concerns, the authors plan to perform a simulation study to determine the appropriateness of applying a Changes to the input data in 2003 assessment include addition of the 2002 fishery age composition, 2002 survey age composition, and 2003 trawl survey biomass point estimate and standard error. This year's bottom trawl survey resulted in a biomass estimate of 2,140,000 t, a 12% increase over last year's estimate of 1,900,000 t. The assessment continued the investigation of catchability (q) began in 2002. Prior to 2002, modeling assumed a catchability (q) of 1.0. Last year's assessment used a catchability (q) of 1.82 based on the fit to all of the population information in the model. Increasing q by this magnitude resulted in estimates of abundance which were approximately half of the previously estimated values. In this year's assessment, a value of 1.4 obtained from a trawl "herding" experiment was used as the mean of a prior distribution on q. The new assessment gives a q estimate of 1.45. This results in estimates of total and female spawning biomass that are higher than last year's estimates but still lower than previous estimates. Biomass of rock sole is expected to decline over the next few years due to below average recruitment observed in the 1990s.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore this stock qualifies for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the

present assessment are 203,000 t, 0.17, and 0.21, respectively. Given that the projected 2004 spawning biomass of 425,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3. The recommended F_{ABC} is at the $F_{40\%}$ (=0.17) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 139,000 t.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.21 gives a 2004 OFL of 166,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The authors responded to a request by the SSC to examine rock sole for possible management under Tier 1. In the case of rock sole, the time series of recruitment estimates from this assessment is 28 years. In the stock assessment model, a Ricker form of the stock-recruit relationship was fit to these data. Very different estimates of F_{MSY} and B_{MSY} were obtained depending on which years of data were included. Recent research indicates a decadal scale shift in atmospheric forcing, which may affects the recruitment of rock sole. Given these concerns, the authors plan to perform a simulation study to determine the appropriateness of applying a harvest strategy resulting from fitting the full time series for a fish stock experiencing temporal less productive reproductive potential due to changing oceanic conditions. Therefore, management under Tier 1 is not recommended at the present time.

Changes to the input data in 2003 assessment include addition of the 2002 fishery age composition, 2002 survey age composition, and 2003 trawl survey biomass point estimate and standard error. This year's bottom trawl survey resulted in a biomass estimate of 2,140,000 t, a 12% increase over last year's estimate of 1,900,000 t. The assessment continued the investigation of catchability (q) began in 2002. Prior to 2002, modeling assumed a catchability (q) of 1.0. Last year's assessment used a catchability (q) of 1.82 based on the fit to all of the population information in the model. Increasing q by this magnitude resulted in estimates of abundance which were approximately half of the previously estimated values. In this year's assessment, a value of 1.4 obtained from a trawl "herding" experiment was used as the mean of a prior distribution on q. The new assessment gives a q estimate of 1.45. This results in estimates of total and female spawning biomass that are higher than last year's estimates but still lower than previous estimates. Biomass of rock sole is expected to decline over the next few years due to below average recruitment observed in the 1990s.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore this stock qualifies for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 203,000 t, 0.17, and 0.21, respectively. Given that the projected 2004 spawning biomass of 425,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3. The recommended F_{ABC} is at the $F_{40\%}$ (=0.17) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 139,000 t.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.21 gives a 2004 OFL of 166,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The authors responded to a request by the SSC to examine rock sole for possible management under Tier 1. In the case of rock sole, the time series of recruitment estimates from this assessment is 28 years. In the stock assessment model, a Ricker form of the stock-recruit relationship was fit to these data. Very different estimates of F_{MSY} and B_{MSY} were obtained depending on which years of data were included. Recent research indicates a decadal scale shift in atmospheric forcing, which may affects the recruitment of rock sole. Given these concerns,

the authors plan to perform a simulation study to determine the appropriateness of applying a harvest strategy resulting from fitting the full time series for a fish stock experiencing temporal less productive reproductive potential due to changing oceanic conditions. Therefore, management under Tier 1 is not recommended at the present time.

Flathead sole

The 2003 assessment updates last year's by incorporating new catch, discard, survey biomass, length composition, and age composition data. The 2003 trawl survey biomass estimate of 530,000 t was about 8% lower than last year's estimate of 575,000 t. Survey biomass has been relatively stable over the past three years compared to the decrease observed from 1998-2000. A change in methodology for this year's assessment investigated the relationship between temperature anomalies and survey biomass anomalies whereby the survey catchability coefficient was modeled as a function of temperature anomalies. This addition had an effect on survey biomass estimates since 1998, during which time temperature fluctuations were greater.

The SSC has determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, thereby qualifying it for management under Tier 3. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ from the present assessment are 119,000, 0.30, and 0.37, respectively. Given that the projected 2004 spawning biomass of 205,000 t exceeds $B_{40\%}$, ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3 where F_{ABC} is set at the $F_{40\%}$ (=0.30) level, the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 61,900 t. The OFL was also determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.37 gives a 2004 OFL of 75,200 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Alaska plaice

This is the second year in which Alaska plaice has been evaluated as a separate species instead of the principal component of the "other flatfish" species group. Minor changes in this year's assessment include adjusting the initial year of the model from 1971 to 1975, changing the age of recruitment in the model from age 1 to age 3 because of limited ages-1 and -2 data, inclusion of the 2003 trawl survey biomass estimate and standard error, updating of the 2002 catch data, and inclusion of fishery catch through September 2003.

There was one major change in the assessment methodology and input data that affected this analysis. In the past, the model used age/length keys based on survey data and applied them to the fishery. The most significant change in the model was the construction of a matrix to convert modeled numbers at age to numbers at length, thus enabling the authors to use length-frequency data as input. This permitted inclusion of 12 years of survey length composition data and 19 years of length data from the fishery. The authors tested the stability of the age/length curve over time and validated the use of a single age/length key. The inclusion of the new length data primarily affected the fishery selectivity curve. There was little change in the survey selectivity, with an age at 50% selection of 9.7 years. However, there was a large change in the age at 50% selection in the fishery selectivity curve from 8.5 years to 10.3 years. The size of the fish (33 cm) at 50% selection is similar to the size at 50% selection for flathead sole (35 cm), implying that the gear is acting similarly on the two species. The change in fishery selectivity doubles the value of F_{40} from 0.28 in last year's assessment to 0.57 in this year's assessment. Additionally, the authors investigated the effect of bottom water temperature on the catchability

of Alaska plaice. No correlation was found and survey catchability remained fixed at a value of 1.0.

Reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist for this stock, therefore qualifying it for management under Tier 3. The updated point estimates are $B_{40\%}$ = 132,000 t, $F_{40\%}$ = 0.57, and $F_{35\%}$ = 0.78. Given that the projected 2004 spawning biomass of 261,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 203,000 t. The OFL was determined from the Tier 3a formula, where projected harvesting at $F_{35\%}$ gives a 2004 OFL of 258,000 t. Though the newly calculated selectivity indices resulted in a 48% increase in ABC over 2003, the sensitivity of the spawning-per-recruit fishing reference points 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 large compared to other flatfish. Because the age at 50% selection in the fishery is 10.3, Alaska plaice has the potential to spawn twice before it is recruited to the fishery. Additionally, the high natural mortality of 0.25 indicates that the lifetime spawner per recruit potential is rapidly reducing at the ages of highest fishing selectivity. Recruitment has been stable from the late 1970s through present. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Other flatfish

With the removal of Alaska plaice from this category last year, 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 85% of the "other flatfish" catch in 2003.

Because of insufficient information about these species, no model analyses are possible. The assessment incorporates 2002 total catch and discard, catch through 20 September 2003, and 2003 trawl survey information. The 2003 EBS bottom trawl survey resulted in biomass estimates of 90,300 t, an 8% decrease from the estimate of 97,900 t in the 2002 survey.

Prior to last year, "other flatfish" had been classified as Tier 4, using the $F_{35\%}$ and $F_{40\%}$ rates for flathead sole as proxies. In 2002, the Plan Team concluded that these fishing mortality reference points may not apply to the species in the "other flatfish" complex due to the variability in natural mortality and other life-history characteristics among flatfish species, and recommended reclassification of "other flatfish" as a Tier 5 species complex with an assumed natural mortality rate of 0.2.

F_{ABC} was set at the 0.75 *M* level (=0.15), which is the maximum permissible level under Tier 5. Projected harvesting at the 0.75 *M* level gives a 2004 ABC of 13,500 t. The overfishing level was set with an F_{OFL} value of 0.20, giving a 2004 OFL of 18,100 t. It is not possible to determine whether the "other flatfish" complex is overfished or approaching an overfished condition because it is managed under Tier 5.

Greenland turbot

This year's model incorporated new catch and length frequency data from the fishery. It also included an aggregated longline survey index and updated trawl survey information on biomass and length frequency data. Biomass and size composition data were also included from the EBS slope survey. The stock assessment model indicates that this stock has continued to decline due to the reduced recruitment levels observed in the last 20 years relative to the strong recruitment observed in the 1970s. The stock is still above the $B_{40\%}$ reference level and is lightly harvested. 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 58,800 t, 0.26, and 0.32, respectively. Projected spawning biomass for 2003 is 69,300 t.

Greenland turbot therefore qualify for management under Tier 3a. The maximum permissible value of F_{ABC} under this tier translates into a 2004 catch of 15,700 t. The assessment authors' recommend setting the 2004 ABC at a value less than the maximum permissible. Using F_{ABC} = 5-year average results in a 2004 ABC of 4,740 t corresponding to a full selection fishing mortality rate of 0.07. The proposed harvest is apportioned by area on the basis of relative survey biomass, giving an EBS ABC of 3,162 t and an AI ABC of 1,578 t. The OFL fishing mortality rate is computed under Tier 3a, $F_{OFL} = F_{35\%} = 0.32$, and translates into an overfishing level of 19,300 t.

Arrowtooth flounder

The present assessment introduced catchability as a function of 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 554,000 t, a 56% increase relative to last year's estimate, but only 26% larger than the 2001 EBS shelf bottom trawl survey. 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 assumed 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. The male natural mortality rate that provided the best fit was 0.32. With the stock assessment model configured in this way, the population biomass was estimated at 696,000 t. This is about 16% less than the peak value estimated for 1995. Thus the stock is in a high and stable condition, but declining slowly from the peak observed in 1995.

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 249,000 t, 0.28, and 0.36, respectively. Given that the projected 2004 spawning biomass of 503,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2004 were calculated under sub-tier "a" of Tier 3 by *se*tting F_{ABC} (=0.28) which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2004 ABC of 115,000 t. The OFL fishing mortality rate under Tier 3a is $F_{35\%}$ (=0.36), or a 2004 OFL of 142,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

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

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New data for this year's flatfish assessment includes the 2003 NMFS bottom trawl survey biomass estimates and the 2003 catch. The 2003 survey only sampled to a depth of 700 m. The 2003 survey biomass estimates were used to calculate ABCs for 2004 for all species except Greenland turbot and deepsea sole, where the mean catch from 1978 to 1995 was used. New data on the maximum age of Dover sole decreased the estimate of natural mortality from 0.10 to 0.085 which is reflected in the 2004 ABC calculations.

The flatfish group is subdivided into arrowtooth flounder, deep water flatfish, flathead sole, rex sole, and shallow water flatfish. Flathead sole and arrowtooth flounder are presented in separate assessments using age-structured models. The 2004 exploitable biomass for each group (except for flathead sole and arrowtooth flounder) is based on results from the 2003 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 ABCs 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).

Greenland turbot and deep-sea sole ABC's were estimated at Tier 6 with ABC=0.75 OFL and OFL=average catch from 1978 to 1995. Total flatfish ABC for 2004 was 7,100 mt greater than the 2003 estimate. ABCs were apportioned among the regulatory areas by applying the average fraction of the catch in each area from 1991 to 1995. As in 2003, the ABC was split between the eastern GOA and the WY and EYAK/SEO sub areas.

A new age-structured assessment of Dover sole was developed and reviewed by the Plan Team. It is expected that the Dover sole will be a separate SAFE chapter next year and the new model will be used.

2004 ABC area apportionment

Flatfish group	Western	Central	WYAK	EYAK/SEO	Total
Deep water	310	2970	1880	910	6,070
Rex sole	1680	7340	1340	2290	12,650
Shallow water	21,580	27,250	2,030	1,210	52,070

Flathead sole

New data for the 2004 flathead sole assessment includes the 2003 survey biomass estimate and length data, and 2003 catch and fishery length data. Analysis of maturity by age and length for the 2003 assessment was used in this assessment to estimate fishing mortality values. Prior to 2002, flathead sole was included in the flatfish complex. The 2004 biomass estimate is based on abundance estimates derived from an age-structured model developed with AD Model Builder software. Model estimates of age 3+ biomass increased from about 256,600 mt in 1984 to about 298,900 mt in 1996, decreased to about 287,000 mt in 2000, then increased to 291,400 mt in 2003, indicating a stable population.

The SSC concludes that reliable estimates of $B_{40\%}$ exist. The projected 2004 female spawning biomass is estimated at 109,980 mt, well above the $B_{40\%}$ level estimated at 47,700 mt. Therefore, flathead sole are in Tier 3a of the ABC and overfishing definitions. Under this definition, $F_{OFL}=F_{35\%}$, and F_{ABC} is less than or equal to $F_{40\%}$. The ABC for 2004 using $F_{40\%} = 0.47$ was estimated at 51,721 mt. The overfishing level using $F_{35\%} = 0.63$, results in 64,750 mt. Area

apportionments of flathead sole ABC's for 2004 (using $F_{40\%}$) are based on the fraction of the 2003 survey biomass in each area:

Western	Central	West Yakutat	East Yakutat/SE	Total
13,410	34,430	3,430	450	51,720

For further information, contact Jack Turnock (206) 526-6549.

Arrowtooth flounder

The 2004 arrowtooth flounder assessment features new biomass and length composition data from the 2003 NMFS bottom trawl survey and updated catch and fishery length data for 2002. The 2004 estimated exploitable biomass of 2,391,550 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 1960s, groundfish trawls in the 1970s, and NMFS triennial trawl surveys from 1984 to 2003 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 2004 female spawning biomass (1,306,460 mt) is greater than the $B_{40\%}$ estimate (620,340 mt). Therefore, $F_{OFL}=F_{35\%}=0.165$ and $F_{ABC}=F_{40\%}=0.142$ resulting in an ABC recommendation that is 39,800 mt larger than last year's estimate (194,930 mt). The overfishing level for arrowtooth flounder is estimated to be 228,130 mt. The Plan Team recommended that ABC be apportioned among regulatory areas in proportion to biomass distributions in the 2003 trawl survey as follows:

Western	Central	West Yakutat	East Yakutat/SE	Total
23,590	151,840	10,590	8,910	194,930

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

10. Walleye pollock

a. Research

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Echo Integration-Trawl Surveys

Winter surveys in the Shumagin Islands and Sanak Trough

The MACE Program conducted Echo Integration-Trawl (EIT) surveys of midwater walleye pollock in the Shumagin Islands area and Sanak Trough between 5 - 12 February, 2003. The Shumagin survey began in Shumagin Trough, then progressed into Stepovak Bay, through the gully off of Renshaw Point and Unga Strait, and ended off the southwest end of West Nagai Island. Parallel transect spacing was 5 nmi in Shumagin Trough, 3 nmi in Stepovak Bay and West Nagai Strait, 2.5 nmi in Unga Strait, and 1 nmi off of Renshaw Point. Sanak Trough was surveyed using 3 nmi parallel transect spacing.

In the Shumagin Islands, the densest aggregations were observed off Renshaw Point, where the majority of pollock exceeded 40 cm fork length (FL). Elsewhere, most of the fish were less than 40 cm FL. The maturity composition for males longer than 40 cm FL was 1% immature, 11% developing, 87% pre-spawning, 2% spawning, and 0% spent. The maturity composition for females longer than 40 cm FL was 3% immature, 13% developing, 73% pre-spawning, 2% spawning, and 9% spent. The high percentage of pre-spawning females suggests that the survey timing was appropriate. Female pollock were estimated to be 50% mature at 41 cm FL and the mean gonado-somatic index (GSI) for mature pre-spawning females was 0.15. Midwater pollock abundance estimates in the Shumagin Islands area are 115 million fish weighing 67 thousand t based on catch data from 10 trawl hauls and acoustic data from 300 nmi of survey transects.

The densest pollock aggregations in Sanak Trough were detected in the northern part of the trough and over half of the echosign was observed on a single transect. Pollock were observed over bottom depths as shallow as 50 m and within 30 m of the surface. The maturity composition for males longer than 40 cm FL was 0% immature, 7% developing, 59% pre-spawning, 15% spawning, and 19% spent. The maturity composition for females longer than 40 cm FL was 2% immature, 15% developing, 52% pre-spawning, 3% spawning, and 27% spent. Female pollock were estimated to be 50% mature at 46 cm FL, and the mean GSI for mature pre-spawning females was 0.14. Midwater pollock abundance estimates are 84 million fish weighing 81 thousand t based on catch data from 4 trawl hauls and acoustic data from 64 nmi of survey transects.

Winter survey in Shelikof Strait and near Chirikof and Middleton Islands

The MACE Program also conducted winter EIT surveys of walleye pollock in the Shelikof Strait area and the continental shelf break areas near Chirikof Island and Middleton Island between 16 - 31 March, 2003. The Shelikof Strait survey covered the area from near Chirikof Island to about Cape Chiniak on the Alaska Peninsula. Parallel transect spacing was 7.5 nmi in the Shelikof Strait area, 8.0 nmi along the shelf break from about 10 nmi east of Chirikof Island to the mouth of Barnabas Trough, and 5 nmi along the shelf break near Middleton Island.

The densest echosign attributed to near-bottom pollock in Shelikof Strait occurred from about 30 nmi northwest of Chirikof Island to Katmai Bay. Similar to the 2001 and 2002 surveys but unlike most other Shelikof Strait surveys, very little echosign was detected north of Katmai Bay along the west side of the Strait, where the bulk of the mature pre-spawning pollock are usually found. Mid-water layers as well as more discrete aggregations of sub-adult pollock, were detected at about 175-200 m depth along some transects. The discrete pollock aggregations were more common during the day than at night. The maturity composition of male pollock longer than 40 cm FL was 8% immature, 22% developing, 24% pre-spawning, 39% spawning, and 0% spent. The maturity composition for females longer than 40 cm FL was 10% immature, 42% developing, 46% pre-spawning, 0% spawning, and 2% spent. The percentage of females in the spawning and spent stage of maturity was similar in 2000-2002 but substantially lower than in 1998 (17%), 1997 (15%), and 1996 (23%). Female pollock were estimated to be 50% mature at 44 cm FL. The mean GSI for mature pre-spawning females of 0.11 was similar to the mean GSI from the 2001-2002 surveys but lower than the mean GSIs (0.14-0.19) reported for other recent (1992-2000) Shelikof surveys, which suggests that the fish may have spawned later in the Shelikof Strait area this year. Midwater pollock abundance estimates are 1.1 billion pollock weighing 270,000 mt based on catch data from 19 trawl hauls and acoustic data from 784 nmi of survey transects. The biomass estimate was 18% higher than the 2002 estimate, which was the lowest in survey history.

Along the Chirikof shelf break, most echosign attributed to midwater layers of pollock occurred between 300 and 500 m depth within the two shelf-break bights between Chirikof Island and Barnabas Trough over bottom depths of 300 to 800 m. No fish shorter than 35 cm FL were caught during the survey. The maturity composition for male pollock longer than 40 cm FL was 1% immature, 4% developing, 74% mature pre-spawning, 21% spawning, and 0% spent. The maturity composition for females longer than 40 cm FL was 0% immature, 8% developing, 92% pre-spawning, 1% spawning, and 0% spent. Female pollock were estimated to be 50% mature at 44 cm FL, and the mean GSI for mature pre-spawning females was 0.15. Midwater pollock abundance estimates are 29 million pollock weighing 30,900 t based on catch data from 8 trawl hauls and acoustic data from 224 nmi of survey transects.

The small amounts of pollock detected east and west of Middleton Island occurred at similar water column and bottom depths to those observed in the Chirikof Island survey area. Adult fish dominated the size composition. The maturity composition for male pollock longer than 40 cm FL was 0% immature, 3% developing, 44% mature pre-spawning, 52% spawning, and 0% spent. The maturity composition for females longer than 40 cm FL was 0% immature, 5% developing, 95% pre-spawning, 0% spawning, and 1% spent. Female pollock were estimated to be 50% mature at 44 cm FL, and the mean GSI for mature pre-spawning females was 0.14. Midwater pollock abundance estimates are 7 million pollock weighing 6,000 t based on catch data from 5 trawl hauls and acoustic data from 131 nmi of survey transects.

Summer survey of western-central Gulf of Alaska from the Shumagin Islands to Prince William Sound

The MACE Program conducted a summer echo integration-trawl feasibility survey in the Gulf of Alaska to determine whether it would be possible to estimate walleye pollock distribution and abundance during this time of year within the Gulf. The study was conducted from 4 June to 16 July 2003 and focused on the western-central portion of the Gulf between the Shumagin Islands and Prince William Sound. The area of operations extended over bottom depths of about 50 m over shallow inshore shelf regions to about 1,000 m beyond the shelf

break. . Survey transects were generally oriented parallel to one another and spaced 20 nmi apart. Areas where the commercial pollock fishing fleet traditionally operates in recent years were surveyed using more closely spaced transects: 2 nmi off Renshaw Point, 3 nmi near Nakchamik Island, Alitak Bay, Barnabas Trough and Chiniak Trough, 3.5 nmi near Mitrofania Island, 4 nmi in West Nagai Strait and Marmot Bay, 8 nmi in Prince William Sound, and 10 nmi in Shelikof Strait. Transect spacing was reduced to 10 nmi along the shelf break area between the Trinity Islands and the mouth of Chiniak Trough and in Amatuli Trough.

The densest pollock aggregations were detected in the vicinity of Kodiak Island in Barnabas and Chiniak Troughs, the Shelikof Strait sea valley, and within Marmot and Alitak Bays. Near-shore pockets of deep water (>150 m bottom depth) also contained pollock echosign, such as off Renshaw Point and off Nakchamik Island. Low densities of diffuse mid-water pollock echo sign were occasionally observed along the shelf break between bottom depths of 300 - 500 m. Virtually no pollock echosign was detected over bottom depths less than 100 m with the exception of Alitak Bay, where substantial amounts of pollock were detected outside the bay over bottom depths of 50-70 m. Trawl hauls conducted in the densest pollock echosign contained mostly fish between 30-45 cm FL. Midwater pollock abundance estimates for the area surveyed were 1.3 billion fish weighing about 320 thousand t based on 93 trawl hauls and acoustic data from 3,470 nmi of survey transects.

Capelin appeared to have the most potential for assessment using EIT survey methodologies of all the other fishes encountered during the survey. This species often aggregated in distinct schools, which did not appear to avoid the trawl. However, capelin escapement through the larger trawl meshes was a problem. For example, dense capelin echosign was often observed with the headrope- and vessel-mounted sounders during trawling. Trawls targeting these dense aggregations would capture relatively few individuals in the codend although large numbers of these fish would be caught in the meshes of the intermediate section of the net. Although a suitable target strength to length relationship for capelin has not yet been developed, target strength data for capelin were recently collected in the GOA. Analysis of these data is currently in progress.

For more information, please contact Michael Guttormsen, (206) 526-4163.

b. Stock assessments

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The age-structured model developed using AD Model Builder and used for GOA pollock assessments in 1999-2002 is fundamentally unchanged. This year's pollock assessment features the following new data: (1) total catch and age composition from the 2002 fishery; (2) biomass and age composition from the 2003 Shelikof Strait echo integration trawl (EIT) survey; (3) biomass and length composition from the 2003 ADF&G coastal trawl survey and age composition from the 2002 ADF&G survey; (4) biomass and age composition for the 2003 NMFS bottom trawl survey; and (5) new ageing error transition matrix using percent agreement between age readers and testers for 1987-2002. The 2003 NMFS bottom trawl survey biomass estimate increased 86% over a comparable area surveyed in 2001. The 2003 Shelikof Strait EIT survey biomass estimate increased 18% over the 2002 estimate, although a continued decline in adult biomass was indicated. In addition, the 2003 ADF&G near shore survey biomass estimate

declined 30% from 2002. Stock concerns include the continued decline in Shelikof Strait spawning activity and continued reduction in estimated size of the 1999 year class.

Two independent reviews of the Gulf of Alaska pollock assessment have been completed and the assessment author addressed the modeling aspects of the reviewer comments but recognized that reviewer suggestions that involve survey design may be financially or practically difficult to implement. Preliminary analysis based on peer reviews suggested: (1) there is no compelling evidence that $F_{35\%}$ is inappropriate as a proxy for F_{MSY}; and (2) fishing effects have not been overly detrimental to GOA pollock recruitment patterns relative to environmental effects.

The stock assessment authors evaluated six models: Model 1 estimated NMFS trawl survey catchability; Model 2 fixed trawl survey catchability at 1.0 (similar to previous assessments) and estimated other catchabilities; Model 3 was similar to Model 2 but excluded the 2002 Shelikof EIT data; Model 4 was similar to Model 2 but excluded the NMFS bottom trawl survey data; Model 5 was similar to Model 2 but excluded the ADF&G 2002 trawl survey data; and Model 6 was similar to Model 2 but excluded the historical NMFS 400-mesh Eastern trawl survey data. The author's recommended selecting Model 2 for stock biomass projections. Successive annual assessments have continued to reduce the estimated strength of the 1999 year class, although it is not clear whether the downward trend in the estimated magnitude of the 1999 year class is attributable to increased predation of juvenile pollock. Several components of conservatism included in Model 2 are: (1) fixing trawl catchability at 1.0; (2) assuming an average 1999 year class instead of the model estimate; (3) not adjusting the 2003 Shelikof strait survey biomass estimate despite evidence suggesting an unexpectedly low fraction of the stock spawned in Shelikof Strait in 2003; and (4) applying a more conservative harvest rate than the maximum permissible F_{ABC}. Using Model 2, results in an ABC of 65,660 mt for GOA waters west of 140 degrees W. longitude. Model results, which assume an average abundance for the 1999 year class, produced an estimated 2004 spawning biomass of 165,580 mt, or 27% of unfished spawning biomass. The $B_{40\%}$ estimate of 248,130 mt for 2004 is similar to estimates in the 2000 to 2002 assessments. Because model estimated 2004 biomass is below $B_{40\%}$, Gulf of Alaska pollock are in Tier 3b. The projected 2004 age-3+ biomass estimate is 740,440 mt under an assumption of average abundance for the 1999 year class. Markov Chain Monte Carlo analysis indicated the probability of the stock being below $B_{20\%}$ to be less than 1% in 2004 and subsequent years. The OFL fishing mortality rate under Tier 3b is 91,060 mt.

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

EASTERN BERING SEA

The present assessment is a straightforward update of last year's assessment, incorporating new data from the 2003 fishery and bottom trawl survey. The 2003 bottom trawl survey estimated a biomass of 8,510,000 t, an increase of 77% relative to the 2002 estimate and the highest estimate in the entire time series. Other new inputs include age composition data from the 2002 fishery and the 2002 echo-integration trawl survey. The 1991-2002 time series of total catch was recompiled for this assessment.

Seven alternative models are presented in the assessment, 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 2004 age 3+ biomass in the range 8,710,000 t to 15,800,000 t.

Model 1, which is identical to last year's model, was chosen as the reference model for the 2004 fishing season.

The current assessment provides results very similar to last year's assessment, with the main difference being that the current assessment's estimates of biomass tend to be slightly higher than last year's assessment.

The SSC has determined that reliable estimates of B_{MSY} and the probability density function for F_{MSY} exist for this stock, and that EBS walleye pollock therefore qualify for management under Tier 1. The senior assessment author continues to feel 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 2,470,000 t, compared to 2,290,000 t from last year's assessment. The projected spawning biomass for 2004 is 4,080,000 t, placing EBS walleye pollock in sub-tier "a" of Tier 1. This year's assessment uses a new method to compute the maximum permissible ABC for Tier 1a. The new method is more consistent with the Tier 1a formula and is based on the ratio between MSY and the equilibrium age 3+ biomass corresponding to MSY. The harmonic mean of this ratio (0.233) is multiplied by the geometric mean of the projected age 3+ biomass for 2004 (11,000,000 t) to obtain the maximum permissible ABC for 2004, 11 which is 2,560,000 t. This ABC is about 1% higher than the 2004 yield corresponding to an $F_{40\%}$ strategy. In each of the last two years, the senior assessment author, Plan Team, and SSC all recommended setting ABC at the maximum permissible value. This year, the senior author again recommends setting ABC at the maximum permissible value.

Given that TAC will necessarily be set below the recommended ABC, the assessment also provides alternative harvest scenarios, including the seven standard scenarios analyzed in all age-structured assessments and two constant catch scenarios (1,300,000 t and 1,500,000 t). The OFL harvest ratio under Tier 1a is 0.250, the arithmetic mean of the ratio between MSY and the equilibrium age 3+ biomass corresponding to MSY. The product of this ratio and the geometric mean of the projected age 3+ biomass for 2004 (11,000,000 t) is the OFL for 2004, which is 2,740,000 t.

Aleutians:

Last year, the SSC determined that Aleutian pollock qualified for management under Tier 5. Because the Aleutian Islands were not surveyed this year, the best available biomass estimate is the estimate of 175,000 t from the 2002 bottom trawl survey. The maximum permissible for 2004 ABC is identical to the 2003 ABC of 39,400 t, which is the recommended ABC. The 2004 OFL is identical to the 2003 OFL of 52,600 t. As a Tier 5 stock, it is not possible to determine whether Aleutian pollock is overfished or whether it is approaching an overfished condition.

Bogoslof:

The 2003 hydroacoustic survey of the Bogoslof region resulted in a biomass estimate of 198,000 t. Last year, the SSC determined that Bogoslof pollock qualified for management under Tier 5. The maximum permisible ABC under Tier 5 is 75% of the product of the natural mortality rate (0.20) and biomass, giving a value of 29,700 t, which is the recommendation for 2004 ABC. For several years, the North Pacific Fisheries Management Council's Plan Team has recommended setting ABC for this stock at the maximum permissible level while the SSC has used a much more conservative approach. If the formula used by the SSC is applied, the resulting fishing mortality rate is 0.014, giving a 2004 ABC of 2,570 t. The overfishing level

under Tier 5 is the product of the natural mortality rate and biomass, giving an OFL of 39,600 t for 2004. As a Tier 5 stock, it is not possible to determine whether Bogoslof pollock is overfished or whether it is approaching an overfished condition.

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

13. Other Species

a. Research

Pacific Sleeper Shark Relative Abundance in the Northeast Pacific

Pacific sleeper sharks (*Somniosus pacificus*) are a deepwater shark of the North Pacific Ocean. Some information suggests their abundance is increasing. Our purpose was to analyze existing sleeper shark data to determine the trend in abundance and whether any change was statistically significant. Last year, we analyzed a long-term time series, 1979-2000, of Pacific sleeper shark bycatch from fishery-independent sablefish longline surveys in Alaskan waters of the northeast Pacific. This year we updated the analysis, adding the years 2001-2003. Results indicated a significant increase in the relative abundance of Pacific sleeper sharks in the central Gulf of Alaska between the years 1989-2003. These results were presented to the Gulf of Alaska Groundfish Plan Team and included in the Ecosystem Considerations Chapter of the Groundfish Plan Team's Stock Assessment and Fisheries Evaluation Report for 2004.

For more information, contact Dean Courtney at (907) 789-6006 or Mike Sigler at (907) 789-6037.

Pacific Sleeper Shark Movement Study

Pacific sleeper sharks (*Somniosus pacificus*) are a deepwater shark of the North Pacific Ocean. We began a movement study of sleeper sharks in 2003. Sleeper sharks were tagged in Chatham Strait, Alaska with two types of tags. The first type are archival tags which record temperature, depth, and time. The recovery method is the sablefish fishery which occurs in Chatham Strait each fall. The second type are sonic tags which if followed by a vessel, indicate local movements. The pilot year was successful, and further work is planned for 2004.

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

D. Other Related Studies

Effects of Fishing on Sea Floor Habitat

Distribution of Deep-water Corals and Associated Communities in the Aleutian Islands

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996, requires the regional Fishery Management Councils and NMFS to minimize, to the extent practicable, adverse effects from fishing on essential fish habitat including coral habitat. Major fisheries presently occur throughout the Aleutian Island Archipelago and down the continental slope to at least a depth of 1,500 m. Summaries of archived data and recently acquired fisheries bycatch specimens indicate that the Aleutian Islands may harbor the highest abundance and diversity of temperate water corals in the world. However, these data reveal little about the distribution of corals in relation to the overall underwater landscape and the importance of corals to marine ecosystems.

In July 2002, Auke Bay Laboratory (ABL) scientists used the manned submersible *Delta* to study Aleutian Islands coral habitat in waters down to 350 m depth near the Andreanof Islands and on Petrel Bank in the Bering Sea. Coral and sponges were found at 30 of 31 dive sites investigated and percent coverage ranged from approximately 5% on pebble substrate to 100% coverage on bedrock outcrops. Unique coral habitat consisting of high density "gardens" of corals, sponges, and other sessile invertebrates was found at 5 sites between 150 and 350 m depth. These "gardens" were similar in structural complexity to tropical coral reefs. This habitat had not been previously documented in the North Pacific Ocean or Bering Sea. Disturbance to epifauna, likely anthropogenically induced, was observed at most dive sites and may have been more evident in heavily fished areas.

Scientists from ABL, the Alaska Department of Fish and Game, and the University of Alaska returned to the central Aleutian Islands in 2003. Multibeam bathymetry and backscatter sea floor maps were created for 17 sites systematically selected between Seguam Pass and Petrel Bank. These maps will be used to classify the habitat within the sites. The manned submersible *Delta* was used in 2003 to collect *in situ* observations and videographic data on strip transects at depths down to 350 m within ten of the mapped sites.

In 2004, *in situ* observations of Aleutian Islands corals will again be collected with the *Delta*. In addition, the ROV *Jason II* will be used to collect *in situ* observations in deeper water down to 3,000 m. Ultimately, the goal is to construct a model to predict the distribution and density of coral habitat throughout the Aleutian Islands based on depth, substrate type, habitat type, oceanographic parameters, and geological features. Fishing effort and predicted coral habitat distribution data will be entered into a geographical information system to create maps showing areas of coral habitat and fishery interaction. The scientific goals of this work are to study the zoogeography, ecology, and life history aspects of deep-water corals. This information will also directly assist managers in developing methods to minimize fishing interactions with coral habitat in the Aleutian Islands.

For more information, contact Robert Stone at (907) 789-6031 or Jon Heifetz at (907) 789-6054.

Growth and Recruitment of an Alaskan Shallow-water Gorgonian

At least 20 species of gorgonian corals inhabit Alaskan waters. Specimens of all but one species have been found incidentally entangled in fishing gear (e.g., hook and line, longlines, trawls, crab pots, and fish traps) and detached from the seafloor. Several species attain large size and provide habitat in the form of structure and refuge for species of demersal fish and invertebrates. The effects of coral habitat alteration on benthic communities are unknown, but may be substantial due to the reported longevity and slow growth rates of cold-water corals. The North Pacific Fishery Management Council is currently considering measures to establish several marine protected areas where gorgonian corals are abundant. A study to examine the growth and recruitment of *Calcigorgia spiculifera*, a shallow-water gorgonian, was established by the Auke Bay Laboratory in 1999 to provide insights into gorgonian growth rates, validate radiometric aging techniques, and elucidate the effects of fishing activities on coral habitat.

Computer image analysis tools were used to measure the linear length of colony branches from digitized video images collected by scuba diving on tagged specimens. Length of a branch was measured along the medial axis from the point opposite its origin. This method provides a permanent record of colony morphometry. Highly accurate measurements are possible with proper colony orientation with respect to the calibration grid and parallel alignment of the camera lens with the grid.

Thirty seven colonies were tagged at 2 sites in southeastern Alaska in July 1999 and thirty colonies were tagged at a third site in 2001. Growth rate was variable for branches from the same colony and also between colonies. Mean branch growth rate at both sites ranged from -1.82 to 14.83 mm yr^{-1} in 2000 and -0.80 to 9.7 mm yr^{-1} in 2001. Growth rates (2000 mean =5.81 mm yr^{-1}, sd =4.99, 2001 mean =2.95 mm yr^{-1}, sd =2.66) measured during both years were generally much lower than those reported for other gorgonians worldwide, including Alaskan *Primnoa*, a deep-water species. Recruitment of new colonies had not occurred at either study site for a minimum of several years indicating that recruitment in this species, at least at our study sites, is a rare sporadic event.

The slow growth rates measured so far in this study, although preliminary, are noteworthy because shallow-water corals are widely believed to have faster growth rates and shorter life spans than deep-water corals. Additionally, recruitment appears to be a rare, sporadic event. Shallow-water gorgonian communities may therefore exhibit slow recovery rates from sea floor perturbations. In 2002 and 2003, the study was expanded to collect samples for examining the reproductive characteristics of *Calcigorgia spiculifera.*

For more information, contact Robert Stone at (907) 789-6031.

Sea Whip (Order Pennatulacea) Resiliency to Simulated Trawl Disturbance

In 2001, scientists at the Auke Bay Laboratory (ABL) conducted a study to investigate the immediate effects of intensive bottom trawling on soft-bottom habitat, particularly in an area colonized by sea whips. Sea whip biological characteristics and their resistance to two levels of trawling were studied near Kodiak Island using both a chartered trawler and the manned submersible *Delta*. Sea whips are highly visible, and changes in their abundance can be readily quantified. Within the study site, at least two species of sea whips (*Halipteris* sp., and *Protoptilum* sp.) were present with densities up to 10 individuals per m^2. Sea whip beds provide

vertical relief to otherwise homogeneous, low relief habitat. Sea whips may be particularly vulnerable because they can be removed, dislodged, or broken by bottom fishing gear. Furthermore, because sea whips are believed to be long-lived, recolonization rates may be very slow. Analysis of the 2001 data is ongoing and will identify immediate bottom trawling impacts to sea whips, including the percentage of sea whips damaged and dislodged.

However, the long-term fate of damaged and dislodged sea whips remains unknown. To address this problem, Auke Bay Laboratory scientists in 2003 initiated new studies to investigate long-term impacts to sea whips. Large (1-2 m) sea whips of the genus *Halipteris* are being observed *in situ* at a study site in Auke Bay and small (<30 cm) sea whips of the genus *Protoptilum* are being observed in laboratory aquaria. The purpose of these studies is to simulate disturbances caused by fishing gear and document the ability of sea whips to 1) survive after having their internal skeleton broken or flesh torn and 2) re-bury themselves after being dislodged.

For the *Halipteris* sp. study, a large bed of these sea whips was found in Auke Bay at a depth of approximately 30 m. Scuba divers placed numbered stakes in the substrate to identify individual sea whips that were randomly assigned to 3 treatment groups and one control group. Treatments included dislodging, breaking of the internal skeleton, and flesh abrasion. Videographic documentation of tagged sea whips was performed approximately weekly for four months and will continue at longer intervals for up to a year or more.

For the *Protoptilum* sp. study, *Protoptilum* specimens were collected from an area of the seafloor heavily colonized by these sea whips in Chiniak Gully near Kodiak Island. A 6-m shrimp trawl was used to collect approximately 300 sea whips from a depth of 145 m. Live sea whips were retained in seawater and held overnight at the NMFS lab in Kodiak and transported by commercial airliner to ABL on the following day. The sea whips were allowed to acclimate before being randomly assigned to control and treatment groups and observed in live tanks lined with 10 cm of fine sediment similar in composition to that found in Chiniak Gully.

Preliminary results indicate that *Halipteris* sp.were more able to recover from dislodgement than *Protoptilum* sp. Fifty percent of dislodged *Halipteris* were able to recover to an upright position compared to just 5% of dislodged *Protoptilum*. Light tissue abrasion to *Halipteris* resulted in minor flesh injuries that did not affect survival. However, mortality among *Halipteris* with fractured axial rods was 100%. Dislodged and damaged *Halipteris* were much more vulnerable to predation by the nudibranch *Tritonia diomedea*, that appeared to illicit a strong scavenging/predatory response to sea whips in contact with the seafloor. In September 2003, a poster presentation of preliminary results from this study was presented at the Second International Symposium on Deep Sea Corals in Erlangen, Germany.

For more information, contact Patrick Malecha (907) 789-6053 or Robert Stone (907) 789-6031.

Habitat Evaluation of Major Fishing Grounds

The Sustainable Fisheries Act of 1996 was passed to attain long-term protection of essential fish habitat, and it specifically requires that NMFS minimize adverse impacts to essential fish habitat by fisheries that it manages. While considerable legal and administrative effort has been expended to meet the requirements of the Act, there has been little effort to observe the habitat where ongoing fisheries occur. NMFS has limited knowledge of bottom habitat where major fisheries occur. Any regulatory measures adopted to minimize impacts

without the knowledge of whether or where vulnerable habitat is at risk may be ineffective or unnecessarily restrictive. This study, initiated by the Auke Bay Laboratory in 2001, is an effort to attain such knowledge.

During summer 2001, high-resolution echosounder data (multibeam and backscatter) and video data were collected on the Portlock Bank area of the central Gulf of Alaska in the vicinity of extensive bottom trawl and longline fisheries for groundfish. The echosounder data were collected by chartered RV *Davidson*, and the video data were collected from the manned submersible *Delta*. The objective of the study was to characterize bottom habitat in or near heavily fished grounds to understand whether habitats in present fishing grounds are vulnerable to ongoing fishing activities. The area mapped by echosounder was about 1,000 km^2 of the outer continental shelf and upper continental slope. Preliminary interpretations of multibeam and backscatter data indicate the presence of at least a dozen different benthic macro- or mesohabitats. The megahabitats of this area are distinctly the result of past glaciation with the glacial deposits presently being reworked and shaped into moderate (cm-m) relief features. Many submarine canyons notch the upper slope and provide steep relief with alternating mud-covered and consolidated sediment exposures. The video data showed little evidence of trawling on the flatter grounds of the continental shelf, where perhaps the relatively level bottom does not induce door gouging and there is a lack of boulders to be turned over or dragged. The most common sessile epifauna were crinoids, small non-burrowing sea anemones, glass sponges, stylasterid corals, and two species of brittlestars. Occasional large boulders located in depressions were the only anomalies in the otherwise flat seafloor. These depressions may have afforded benthic fauna some protection from fishing gear, as the glass sponges and stylasterid corals attached to these boulders were larger than were typically observed. In the fished areas of the upper slope, there was evidence of boulders turned over or dragged by trawling. The uneven bottom of the slope may have induced gouging by the trawl doors. The substrate was mostly small boulders, cobble, and gravel. Presently there does not appear to be much habitat within the entire study area that can be damaged by trawl impacts. No large corals and very few large sponges were seen. Whether this is the result of past trawl activity is unclear.

During 2002 and 2003, the study was expanded to include additional areas. High-resolution echosounder data were collected by the RV *Davidson* on the Pamplona Spur and South Yakutat Valley areas of the eastern Gulf of Alaska and in the vicinity of Albatross Bank in the central Gulf. The areas mapped by echosounder were 162 km^2 of Pamplona Spur in water depths of 120 m to 940 m, 372 km^2 of the Yakutat Valley in water depths of 190 m to 1,045 m, and 340 km^2 of Albatross Bank in water depths of 20 to 810 m. These mapped areas were also in the vicinity of extensive bottom trawl and longline fisheries for groundfish. Video data of the bottom previously were collected in some of the mapped areas from the manned submersible *Delta*. The objective of the 2002 and 2003 study was similar to that of the 2001 study (i.e., characterize bottom habitat in or near heavily fished grounds) and also to compare these findings to those obtained from the 2001 survey of Portlock Bank. Analysis of the 2001- 2003 data is ongoing.

For more information, contact Jon Heifetz at (907) 789-6054.

Short-term Trawling Effects and Recovery Monitoring (Eastern Bering Sea, 2001-present)

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 CHPZ1 closed area, approximately 25-50 mi south and west of the chronic effects site (above, item #4). In 2001, 6 pairs of predesignated 10-mi long research corridors were sampled before and after a trawling disturbance with commercial gear. Biological sampling consisted of 15 min research trawls for epifauna (n=72 total) and 0.1 m2 van Veen grab samples for infauna (n=144 total at 2 per epifauna site). At each infauna sampling site, a second grab sample (n=144 total) was collected for characterizing carbon and nitrogen levels in surficial sediments, as well as grain size properties. The experimental and control corridors were also surveyed before and after trawling using a Klein 5410 side scan sonar system, to evaluate possible changes in sediment characteristics and bedforms. The 2001 study aimed to quantify short-term changes in the experimental corridors due to trawling. To investigate the recovery process, these same corridors were resampled in 2002. Data are being processed and further studies are being planned.

Effects of Long-term Bottom Trawling in the Eastern Bering Sea (1996-2003)

Chronic bottom trawling may decrease the numbers of individuals of the affected marine population or their mean body size, thereby influencing the structure and function of populations, communities and ecosystems. Using data from the original study in 1996, the mean sizes (kg) of 16 invertebrate taxa in heavily trawled (HT) and untrawled (UT) areas straddling the Crab and Halibut Protection Zone 1 (CHPZ1; area 512) closed area boundary in Bristol Bay were compared. For comparison with experimental results, natural size variability of benthic invertebrates was estimated by examining catches at standard NMFS trawl survey stations located within the CHPZ1 closed area.

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

Reconnaissance Mapping with Side Scan Sonar

A reconnaissance of Bristol Bay seafloor habitats was undertaken using a high-resolution 500 kHz side scan sonar (Klein 5410). The reconnaissance effort was centered on an 800 mi2 area of central Bristol Bay that has never been surveyed by NOAA hydrographers. A 150 m swath of bathymetric data and imagery were collected along survey lines totaling nearly 600 linear miles. The survey intentionally intersected six of the Bering Sea trawl study corridors currently being studied (above, item #5) in order to provide a spatial context for these results. In support of coordinated EFH characterization studies in the area, the reconnaissance survey also crossed 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. The imagery is currently being processed and will be classified using supervised (geological) and unsupervised (statistical) methods in an effort to identify large homeogenous regions that would be the basis for more systematic study of mobile gear effects. Suitability for EFH characterizations will also

be considered. In early 2003, the Klein system was co-purchased with the NOAA Office of Coast Survey (OCS) using accrued lease credits.

EFH Characterization/Mapping

Evaluating Single Beam Echosounders for Synoptic Seabed Classification

Collaborative analyses with the Quester Tangent Corporation, Sidney, B.C. (QTC) are continuing in order to develop an optimum seabed classification scheme for the eastern Bering Sea shelf. The standard QTC method uses a set of proprietary algorithms based on Principal Components Analysis (PCA) to extract features from individual echoes. PCA reduces the full set of features to the three linear combinations that explain a large fraction of echo (seabed) variance. A three-factor cluster analysis then groups the echoes into distinct seabed types based on their acoustic diversity. New techniques being incorporated into this process include fully-automated, objective clustering using the Bayesian form of the Akaike Information Criterion (BIC, or "cost function"), and global minima search in multi-dimensional spaces using simulated annealing (SA). Data being analyzed are echo returns from the seafloor simultaneously collected at two frequencies (38 and 120 kHz) along a 9,000 nm trackline in the eastern Bering Sea during a 1999 hydroacoustic fishery survey by the Miller Freeman. Once this is accomplished, it will be possible to evaluate the system for benthic habitat studies using standardized measures of fish and invertebrate abundance from annual trawl surveys.

Studies on Sea Lion/Groundfish Interactions:

Seasonality of Prey Availability in Regions of Contrasting Steller Sea Lion Abundance Trends

The Auke Bay Laboratory (ABL) began research in 2001 to test the hypothesis that sea lion prey diversity and seasonality are related to Steller sea lion population trends. The decline in the western population of Steller sea lions may be due to decreased prey availability; this decrease may be exacerbated by fishery removals of prey in sea lion habitat. Area-specific diet diversity and population change of Steller sea lions also appear to be related, with faster declines in areas of lower diet diversity (Merrick et al. 1997). Steller sea lions also may switch diet seasonally, as different prey become more available. The purpose of this set of studies is to test the hypothesis that sea lion prey diversity and seasonality are related to Steller sea lion population trends. The approach is to measure Steller sea lion prey, prey quality (energy density), and predator abundance and fishery removals near selected rookeries and haul-outs, emphasizing seasonal measurements conducted during critical life stages of Steller sea lions. Two regional trend areas, southeast (SE) Alaska and the Kodiak area, are being compared. Study haul-outs and rookeries were selected based on year-round accessibility; simultaneous sampling of sea lion abundance, distribution, and diet (scats) is occurring by other cooperating agencies. The University of Alaska currently is conducting a seasonal study on Kodiak Island, an area where Steller sea lion abundance is declining. The ABL is studying sites in SE Alaska, where Steller sea lion abundance has been slowly increasing. In SE Alaska, ABL is cooperating with the Alaska Department of Fish and Game, the University of Alaska, and the University of

British Columbia. This study also is being coordinated with the existing University of Alaska study on Kodiak Island.

For ABL's SE Alaska study, two study sites were selected where Steller sea lions are known to haul-out in relatively large numbers: 1) Benjamin Island, north of Juneau, and 2) the Brothers Islands in Frederick Sound. Field work began in March 2001, and each site has been visited on at least a quarterly basis since then. Prey abundance at each site is determined by echo-integration and midwater trawling, and sea lion scat is collected from the haul-outs to infer diet. Fish are also collected for proximate and free fatty acid analysis. These studies will be completed in May 2004.

For more information, contact Michael Sigler at (907) 789-6037.

Availability of Nearshore Prey to Steller Sea Lions at Two Haul-Outs in Southeastern Alaska

To better understand the declining abundance of Steller sea lions (SSL) in central and western Alaska, we examined the seasonal availability of SSL prey in southeast Alaska where SSL abundance is increasing. From 2001-2004, we identified prey in nearshore waters <100 m deep near two SSL haulouts in summer and winter. Study areas were Benjamin Island, a seasonal haulout used by up to 800 SSLs, and the Brothers Islands, a year-round haulout used by up to 1,500 SSLs. Available prey species were inventoried by beach seine, jig , and ROV within 7 km of each haulout.

Regardless of sampling method, total catch was always greater at the Brothers Islands than at Benjamin Island and was greater in summer than in winter. Mean total seine catch in summer (all years) was nearly 57,000 fish representing 37 species at the Brothers Islands, compared to about 4,000 fish representing 30 species at Benjamin Island. Mean total seine catch in winter (all years) was 328 fish representing 25 species at Brothers Islands and 125 fish representing 21 species at Benjamin Island. Seine catches were dominated by walleye pollock, Pacific sand lance, and Pacific herring in summer and armorhead sculpin, tubesnout, and rock sole in winter. Jig catches ranged from 9 to 1 fish per rod hour in summer and winter. Fish captured by jig were larger (mean FL >190 mm) than fish captured by seine (mean FL <100 mm). Jig catches were dominated by armorhead sculpin, Pacific cod, dusky rockfish, walleye pollock, and yellowfin sole. Few species were observed with the ROV that were not captured by seine or jig. Sixteen species that we captured have been identified in SSL scat at either haulout. More prey is available to SSLs in summer than in winter in nearshore areas.

For more information, contact John Thedinga at (907) 789-6025 or Scott Johnson at (907) 789-6063.

E. Other Items

Groundfish Bottom Trawl Survey Standardization - RACE

The AFSC experienced the first year of survey operations subject to standardization protocols developed during the National Trawl Survey Standardization Workshop in November

2002. Our experiences implementing the protocols in the field were generally positive. Most problems encountered dealt with the standards for measuring and marking trawl warps prior to beginning survey sampling. After implementing the measuring/marking protocol in the field, we concluded that the degree of precision called for by the specifications was unrealistic considering the measuring equipment we currently use. Better measuring equipment, whether installed as fixed metering blocks or temporary-use meters, are required. Until then, we need to establish our specifications more realistically. Operational protocols, those dealing with how each step of the sampling process is accomplished, had been well-written and implementing them worked out well.

Trawl gear studies conducted by the Groundfish Assessment Program over the last couple years have focused on issues closely related to obtaining reliable, consistent samples with our standard trawls. We have investigated the effects on trawl geometry and catching efficiency due to changes in speed through the water, tow duration, unequal warp length, whether autotrawl systems are used, and even the cumulative effect of the instruments hung on the trawl to monitor its performance. Investigators have used several tools to look at these problems, including trawl mounted video cameras, auxiliary "underbags" hung below the footrope, and multiple bottom contact sensors mounted at various points along the bridles and footrope. Footrope contact has been shown to decrease with increased towing speed, suggesting that trawl speed might best be standardized to speed through the water rather than speed over ground, as currently used. Using autotrawl systems, as opposed to locked winches, has been shown to improve the bottom-tending characteristics of the trawl's footrope. Relative bottom contact and fishing dimensions have been evaluated for varying degrees of difference between trawl warp lengths. A decrease in tow duration from 30 to 15 minutes was shown to increase the CPUE of some species (snow crab) while having no effect on the CPUE of others (red king crab). More studies are being planned.

For further information, please contact Dr. David Somerton (206) 526-4116 or Ken Weinberg (206) 526-6109.

GIS Resources

No notable new developments, though some projects are in the works.
For more information, contact Jan Benson (206) 526-4183.

APPENDIX I - Alaska Fisheries Science Center Groundfish Publications - 2003 and In Press
(AFSC authors in bold text)

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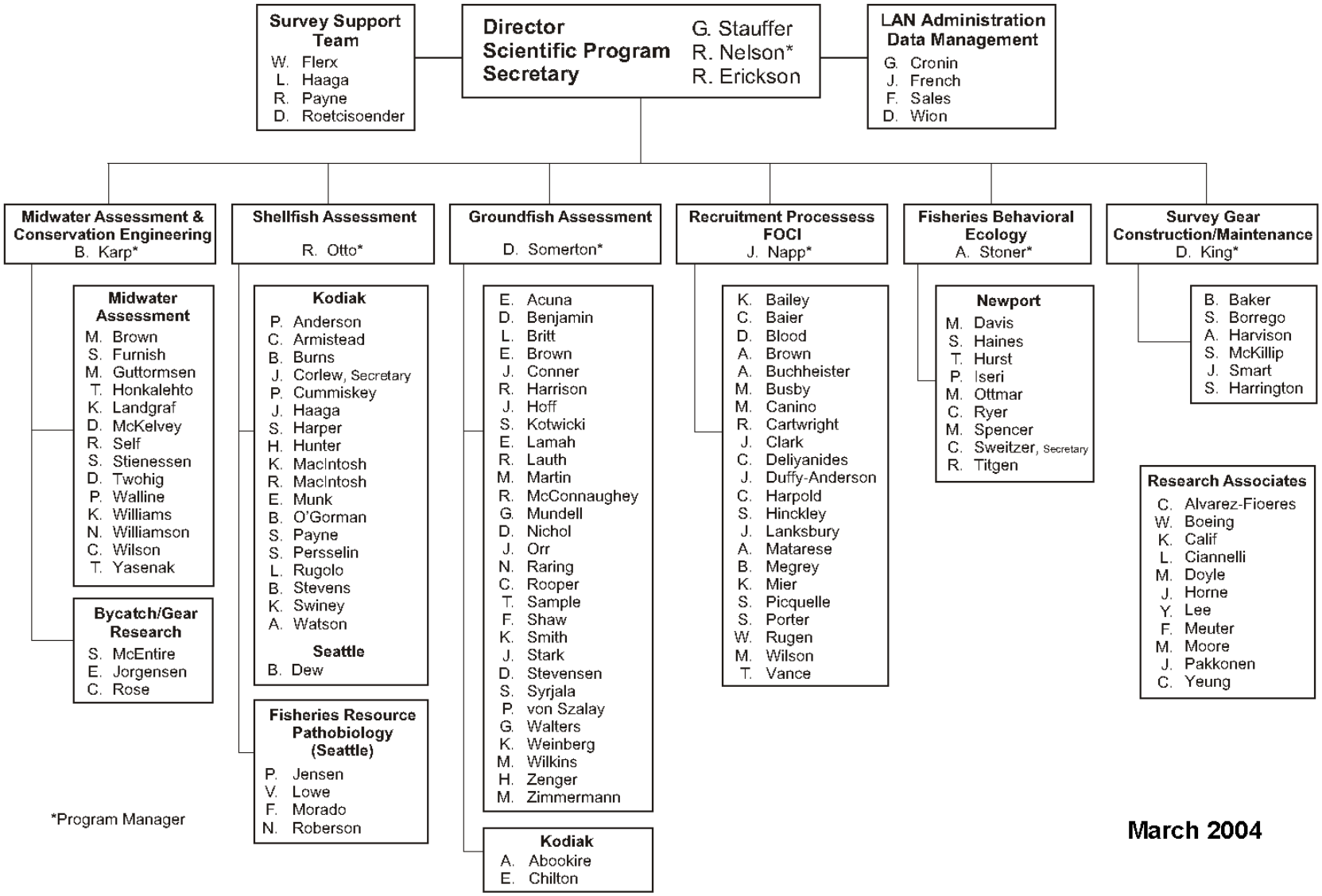
APPENDIX II.--RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION ORGANIZATION CHART 2003



*Program Manager

March 2004

APPENDIX III.--RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION

Richard Marasco -- Director

Loh Lee Low -- Deputy Director

North Pacific Groundfish Observer Program

Ito, Daniel -- Supervisor
Barbeaux, Steven
Barns, Alison
Berger, Jerry
Campbell, Glenn
Corcoran, Andrew
Corey, Sheryl
Dakan, John
Davis, Sharon
Decker, Daniel
DeMorett, Kim
Dixon, Brian
Dunn, Ed
Ferdinand, Jennifer
Fitzgerald, Shannon
Hewitt, Robert
Kenney, Heather
Kruse, Kenneth
Limpinsel, Douglas
Loefflad, Martin
Loomis, Todd
Maier, Robert
Mandina, Stephanie
Martin, Troy
McCauley, Kathleen
Middleton, Angela
Moser, John
Narita, Ren
Neidetcher, Sandra
Nordeen, Carrie
Reeves, Brenda
Ridley, Patricia

Age Determination Unit

Kimura, Daniel -- Supervisor
Anderl, Delsa
Blaisdell, Mark
Gburski, Christopher
Goetz, Betty
Hutchinson, Charles
Johnston, Chris
Kastelle, Craig
Price, Tim
Roberson, Nancy
Shockley, Wes
Short, Jonathan

Observer Program (continued)

Risse, Peter
Seither, Russ
Swanson, Rob
Teig, Karen
Thompson, Lisa
Vijgen, Alison
Watson, Jennifer
Weikart, Heather

Status of Stocks and Multispecies Modeling

Hollowed, Anne -- Supervisor
Bailey, Michael
Dorn, Martin
Fritz, Lowell
Gaichas, Sarah
Ianelli, James
Ingraham, James
Lowe, Sandra
Munro, Peter
Pearce, July
Spencer, Paul
Thompson, Grant
Turnock, Jack
Wennberg, Sherrie
Wilderbuer, Thomas

Resource Ecology and Ecosystems Modeling

Livingston, Patricia -- Supervisor
Buckley, Troy
Derrah, Christopher
Goiney, Bernard
Lang, Geoffrey
Yang, Mei-Sun

Socio-Economic Assessment

Terry, Joe -- Leader
Felthoven, Ron
Hiatt, Terry
Lee, Todd

Revised May 2004

APPENDIX IV - Auke Bay Laboratory Groundfish Assessment Program Staff

Name	Duties
Phil Rigby	Program Manager
Dave Clausen	Rockfish, Gulf of Alaska Groundfish
Dean Courtney	Rockfish, Sharks, Stock Assessment
Dave Csepp	Sea Lion Prey/Predation
Linc Freese	Effects of Fishing, Sponge Life History
Jeff Fujioka	Sablefish, Rockfish, Stock Assessment, Effects of Fishing
Dana Hanselman	Rockfish, Stock Assessment
Jon Heifetz	Effects of Fishing, Rockfish, Sablefish, Stock Assessment
Leland Hulbert	Sea Lion Prey/Predation, Sharks
John Karinen	Gulf of Alaska Groundfish
Mitch Lorenz	Essential Fish Habitat
Chris Lunsford	Rockfish, Sablefish, Stock Assessment, Longline Survey
Patrick Malecha	Effects of Fishing
Nancy Maloney	Sablefish Tag Database, Longline Survey, and Seamounts
Tom Rutecki	Sablefish, Webmaster
Mike Sigler	Sablefish, Stock Assessment, Sea Lion Prey/Predation
Robert Stone	Effects of Fishing, Coral Life History

Other ABL Staff Working on Groundfish

Scott Johnson	Essential Fish Habitat, Sea Lion Prey
John Thedinga	Essential Fish Habitat, Sea Lion Prey
Bruce Wing	Groundfish Early Life History, Corals
Christine Kondzela	Rockfish Genetics