Alaska Fisheries Science Center
of the
National Marine Fisheries Service

2000 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

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 recent publications and reports produced by RACE, REFM, and ABL scientists are presented as Appendix I. Lists or organization charts of groundfish staff of these three units are included as Appendices II, III, and IV.

Dr. Jim Balsiger is leaving the Directorship of the AFSC in May to assume the duties of the NMFS Alaska Regional Director in Juneau. Until a new Science Center Director is selected, Deputy Director Jim Coe will assume those duties.

RACE DIVISION

In 1999 the primary activity of the Resource Assessment and Conservation Engineering (RACE) Division continued to be fishery-independent stock assessments of important groundfish species of the northeast Pacific Ocean and Bering Sea. In response to the needs of the groundfish management community, RACE is changing our triennial rotation of survey area emphasis to a biennial rotation beginning in 1999. We will be surveying the Gulf of Alaska continental shelf and slope during odd years and the Aleutian Islands shelf and Bering Sea continental slope in even

years. The eastern Bering Sea shelf will continue to be surveyed annually for crab and groundfish resources. Currently, plans call for continuing the West Coast shelf and slope trawl surveys in 2000 and 2001, with the goal in mind of transferring those responsibilities to the NWFSC in following years. Three major bottom trawl surveys of groundfish resources were conducted in 1999 by RACE researchers in the Gulf of Alaska, the eastern Bering Sea shelf, and the West Coast slope. The Midwater Assessment and Conservation Engineering (MACE) Program conducted comprehensive acoustic/trawl surveys of pollock abundance in the Bogoslof Island area in February-March 1999 and on the eastern Bering Sea shelf in June-July 1999. The Recruitment Processes task conducted seven Fisheries-Oceanography Coordinated Investigations (FOCI) cruises during the spring and summer of 1999, investigating the interaction between the environment and the spawning products of Gulf of Alaska and eastern Bering Sea pollock.

Dr. William Karp rejoined the RACE Division in 1999 as the new manager of the Midwater Assessment and Conservation Engineering (MACE) Program. Dr. John Horne also joined MACE in October. Dr. Allen Stoner replaced Dr. Bori Olla (retired) as leader of the Fisheries Behavioral Ecology Program in Newport, Oregon. Alisa Abookire and Liz Chilton also joined the RACE Division over the past year; both are groundfish biologists stationed at the Kodiak Laboratory. Janet Duffy-Anderson and Loren Tuttle joined the FOCI program. George Cronin and Phil Porter joined our computer support group.

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, and Status of Stocks and Multispecies Assessment. Scientists at AFSC assist in preparation of stock assessment documents for groundfish in the three management regions (Bering Sea/Aleutian Islands, Gulf of Alaska, and Washington-Oregon-California), conduct research to improve the precision of these assessments, and provide management support through membership in regional groundfish management teams.

Dr. Dan Ito replaced Dr. William Karp as the manager of the Observer Program last fall.

For more information on overall REFM Division programs, contact Division Director Dr. Richard Marasco at (206)526-4172.

NMFS - AFSC - AUKE BAY LABORATORY

The Auke Bay Laboratory (ABL), located in Juneau, Alaska, is a division of the NMFS Alaska Fisheries Science Center (AFSC). ABL's Groundfish Assessment Program is primarily involved with research and assessment of sablefish and rockfish in Alaska and with the study of

fishing effects on the benthic habitat. Presently, the groundfish task is staffed by 13 scientists. One personnel change in 1999 was the hiring of Dean Courtney to work on rockfish assessment and sablefish research.

In 1999 field research, ABL's Groundfish Program, in cooperation with the AFSC's RACE Division, conducted the annual NMFS sablefish longline survey in Alaska. Other field work by ABL included 1) the second year of an experimental rockfish trawl survey that investigated a new survey methodology, adaptive sampling; 2) the second year of a manned submersible study that compared the seafloor habitat in trawled and untrawled areas; 3) continued juvenile sablefish studies; 4) an ongoing study to identify rockfish larvae to species; 5) a sablefish longline hook spacing experiment; and 6) a continuing habitat study of rockfish in nearshore areas of southeastern Alaska.

Ongoing analytic activities involved management of ABL's sablefish tag database and preparation of three annual status of stocks documents for Alaska groundfish: sablefish, slope rockfish, and pelagic shelf rockfish. Other studies included development of an age-structured model for northern rockfish; a study of the northern rockfish fishery and of distribution and biology of this species; and an analysis of how individual quota management has affected the sablefish longline fishery in Alaska. Also, the ABL Groundfish Program, along with the AFSC's RACE and REFM Divisions, developed a multi-year plan for future research on the effects of fishing on bottom habitats 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 May 23- July 11, 1999. A total of 373 stations were sampled covering over 500,000 km^2 from inner Bristol Bay to the shelf edge and from Unimak Pass to 62^o N near St. Matthew Island. The chartered vessels F/V *Aldebaran* and F/V *Arcturus* were used for the survey for the seventh consecutive year. Preliminary biomass estimates for major roundfish species indicated significant increases while most flatfish species were significantly down in abundance from 1998. Due to a change in the walleye pollock 'B' fishing season, the survey was started approximately 2 weeks earlier than in recent years. The combination of the earlier start and an extremely late ice retreat resulted in the coldest water temperatures ever experienced during the time series of eastern Bering Sea surveys. The late ice retreat was considered to be the major cause of the colder temperatures. The mean bottom temperature for the entire survey was 0.81°C (previous low mean was 1.6°C). Almost a third of the stations had bottom temperatures at or below 0°C.

Distributions of walleye pollock and Pacific cod were shifted significantly westward over what is found in most years, possibly indicating a preference for the slightly warmer waters of the outer shelf. Although flatfish populations exhibited much less change in distribution, it is

hypothesized that the extremely cold waters may have reduced trawl herding and reaction to the footrope, thereby reducing catchability.

In addition, a high incidence of the lack of new eggs in red king crab was found, suggesting a delay in molting. As a result, after the completion of the standard survey, the primary area of red king crab abundance was resurveyed and a normal condition was found.

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

West Coast Trawl Survey of Upper Continental Slope Groundfish Resources - RACE

The RACE West Coast Groundfish Team completed a bottom trawl survey of the groundfish resources of the West Coast upper continental slope (WCUCS) between the U.S.-Canada border and Point Arguello (lat. 34_50'N) in waters 183-1,280 m deep from 14 October to 19 November aboard the NOAA ship *Miller Freeman*. This was the eleventh survey in an ongoing series to monitor long-term trends in the distribution and abundance of WCUCS groundfish populations. Previous groundfish assessment surveys of the West Coast upper continental slope were conducted in 1984, from 1988 to 1993, and from 1995 to 1997. Two hundred seven tows were attempted during the 1999 survey. Out of 208 possible stations, 199 were sampled successfully. Remaining attempted tows were unsuccessful due to poor or uncertain gear performance. Nine stations were abandoned without any attempt because extensive acoustic surveys of the sites revealed they were too rough or steep for successful completion of a standardized tow. Resource information from this survey series is used to assess and manage several WCUCS species including sablefish, shortspine thornyhead, longspine thornyhead, and Dover sole. Results from this survey will be published in May in a data report which will be available from AFSC.

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

1999 Gulf of Alaska Biennial Groundfish Assessment Survey - RACE

The first in the new series of biennial bottom trawl surveys of Gulf of Alaska (GOA) continental shelf and slope groundfish resources was conducted from May 10 through July 28, 1999, by RACE scientists. Prior to the 1999 survey, groundfish resources in the GOA had been surveyed triennially since 1984. The continental shelf was surveyed in all previous years but the continental slope had only been included in 1984 and 1987.

The 75-day survey was conducted aboard three chartered commercial trawlers, the *Dominator*, the *Vesteraalen*, and the *Morning Star*. Sampling began near the Islands of Four Mountains (170° W longitude) and extended eastward throughout the GOA to Dixon Entrance (132° 30' W longitude). The primary purpose of the biennial groundfish surveys is to build a standardized time series of data designed to describe and monitor the distribution, abundance, and biological condition of various GOA groundfish stocks. Specific objectives of the 1999 survey were to:

1. Define the distribution and relative abundance of the principal groundfish and invertebrate species inhabiting the Gulf of Alaska;

2. Collect data to define various species-specific biological parameters *i.e.*, age, sex, size, growth rates, length-weight relationships, and feeding habits;
3. Collect integrated net configuration and position data for all trawl hauls to obtain precise area-swept estimates;
4. Record surface-to-bottom water column temperatures; and,
5. Perform special collections as requested by cooperating research groups.

The GOA biennial survey area is dominated by the continental shelf (depths to 200 m) which is crossed by numerous gullies or troughs, some as deep as 300 m. The shelf represents approximately 71% of the 319,884 km^2 survey area and gullies represent another 17%. The shelf width increases from approximately 18.5 km in the Unalaska Island- Islands of Four Mountains region to 185 km off the Kenai Peninsula. The continental slope (200-1,000 m) represents approximately 12% of the survey area.

We sampled each pre-selected station (or nearby alternate station) with a 15-minute trawl haul. Station depths ranged from 16 m to 946 m. Standard RACE Division Poly Nor'Eastern high opening bottom trawls rigged with roller gear were used for sampling at most stations. Experimental sampling was conducted with reinforced Poly Nor'Eastern nets equipped with tire gear at sites previously found to be too rugged for the standard roller gear trawl, however data collected with these trawls were not used to estimate relative abundance and biomass. Catches were sorted to species, weighed, and enumerated. Size composition and a variety of biological data and specimens including age structures, lengths, and weights were collected from target species.

Of the 832 standard survey tows attempted, 764 tows were successfully completed. Together, arrowtooth flounder, Pacific ocean perch, Pacific halibut, walleye pollock, giant grenadiers, and Pacific cod represented nearly 70 percent of the total survey catch. Arrowtooth flounder, by far the most abundant species in the survey, had an estimated biomass of 1.3 million t with 67 percent occurring in the cental GOA. Pacific ocean perch was the second most abundant species and 84% of its biomass estimate was located in the Central GOA. Walleye pollock was third most abundant with 68% of its biomass estimate coming from the Western GOA. Pacific halibut, giant grenadiers, and Pacific cod ranked 4^{th}, 5^{th}, and 6^{th}, respectively. Nearly all giant grenadiers were caught at stations deeper than 500 m. Abundance estimates are presented in Table 1.

Table 1. Biomass (t) of major groundfish species captured during the 1999 Gulf of Alaska biennial groundfish assessment survey.

Species	Western GOA	Central GOA	Eastern GOA	All Areas
Arrowtooth flounder	140,433	848,859	273,505	1,262,797
Pacific ocean perch	37,670	612,011	77,104	726,785
Walleye pollock	430,880	161,180	40,703	632,763
Pacific halibut	112,350	414,452	56,054	582,856
Giant grenadier	108,476	240,460	37,376	386,312
Pacific cod	111,266	172,839	21,719	305,823
Northern rockfish	45,148	196,604	118	241,870
Flathead sole	49,295	139,627	18,599	207,520
Sablefish	13,174	101,234	53,993	168,402
Southern rock sole	44,756	54,411	6,355	105,522
Shortspine thornyhead	14,090	32,592	30,671	77,353
Rex sole	12,333	42,796	19,477	74,605
Dover sole	1,430	34,322	38,615	74,367
Northern rock sole	44,731	16,319	31	61,082
Rougheye rockfish	6,155	20,818	12,683	39,655
Shortraker rockfish	2,208	12,391	13,633	28,232

For further information, contact Eric Brown, (206) 526-4157.

RACE Participation in ADF&G Gulf of Alaska Seasonality Study

AFSC scientists continued their participation in an ongoing ADF&G GOA seasonality bottom trawl study of Marmot Bay off Kodiak and Afognak Islands in January, March, and June of 1999. We collected ovaries from flathead sole, cod, and rock sole; otoliths from cod, flathead sole, and pollock; and stomachs from cod, pollock, halibut, flathead sole and rock sole species. We also used the AFSC's Scanmar equipment to collect net width and height data at each station. These data will be used to evaluate effort from their standard summer survey.

For further information, contact Eric Brown, (206) 526-4157.

Fisheries Behavioral Ecology Program - RACE

Led by Dr. Allen Stoner, this research program, located at the Hatfield Marine Science Center in Newport, Oregon, focuses on understanding the role that behavior plays in regulating the growth, distribution, abundance, and survival of economically and ecologically valuable fish species. Two major groups of laboratory studies are conducted. Bycatch research focuses on the potential for recovery of juvenile and adult walleye pollock, sablefish and halibut that initially survive capture or are otherwise impacted by fishing gear. Behavioral ecology research focuses

on larval, juvenile and adult stages of walleye pollock and sablefish and their responses to changing environmental conditions and how these influence distribution, growth and survival.

Bycatch studies are aimed at evaluating: 1) the potential for long-term survival following capture; 2) whether fish that survive capture suffer deficits in behavioral and physiological capabilities that may compromise their ability to feed successfully and avoid predation; 3) whether the capability of surviving and recovering from capture differs with age and species; 4) how environmental factors interact with stresses imposed by capture to influence survival and recovery of behavioral and physiological capabilities. Recent results have shown that in walleye pollock, sablefish and halibut, survival and recovery of feeding, predator evasion and baseline physiology after capture is dependant on gear type (towed net or longlining). The speed and duration of towing in a net or the length of time on a longline can affect behavior and survival. The light conditions in a net are important, with fish under dark conditions being unable to orient or swim, a condition that results in greater injury, behavioral deficits and mortality. Sensitivity to capture stress varies among ages and species, with walleye pollock being the most sensitive species and younger fish being more sensitive than older fish, a result that shows that generalizations about bycatch stress and mortality among species is not possible. Elevated temperature plays a major role in the magnification of stress that is induced by capture. Exposure of fish to temperatures ranging from 12 to16°C after capture, a condition that is similar to thermocline conditions and deck conditions off the northwest coast of the U.S. and Canada during the summer, results in magnification of behavioral and physiological deficits as well as mortality. Clearly, management of fisheries stocks should consider the impact of seasonally elevated temperature on the increase in bycatch stress and mortality for all gear types.

Behavioral ecology studies on various stages of walleye pollock and sablefish include experimental analysis of feeding and growth, predator/prey interactions and social interactions (schooling and resource competition) in response to physical gradients of light, temperature, and mixing and temporal and spatial distribution of food, predator threat and social interactions. Results are assessed in conjunction with field studies to help improve sampling surveys, predict responses by fish to changes in their environment and ultimately, predict survival and recruitment potential.

For further information, contact Michael Davis, (541) 867-0256 .

Fisheries Resource Pathology Program - RACE

The Fisheries Resource Pathobiology sub-task continued its monitoring effort of potentially important diseases of juvenile walleye pollock, red (*Paralithodes camtschaticus*) and blue (*P. platypus*) king crab, and three species of tanner crabs (*Chionoecetes bairdi, C. opilio,* and *C. tanneri*) during the 1999 survey season. Juvenile walleye pollock (20 – 90 mm) were collected from the Bering Sea and will be microscopically examined to determine the prevalence and distribution of diseases that may lead to mortality prior to recruitment age. To determine the distribution and prevalence of Bitter Crab Syndrome caused by the parasitic dinoflagellate *Hematodinium* sp., hemolymph smears were collected from *Chionoecetes bairdi* and *C. opilio* from the Bering Sea and from *C. tanneri* from the West Coast. Ongoing studies of disease prevalence and distribution in red and blue king crab were continued during the 1999 survey

season. Tissue samples were fixed and will be microscopically examined to determine disease affects on population abundance and distribution.

For further information, contact Dr. Frank Morado, (206) 526-6572 .

Age and Growth Task - REFM

The Age and Growth Program of the REFM Division serves as the Alaska Fisheries Science Center's ageing unit for groundfish species. The program consists of a biometrician, age validation researcher, data manager/technician, and 8 age readers. Ages are usually determined from otoliths, but scales and/or finrays 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.

Craig Kastelle's radiometric ageing study on Pacific ocean perch, shortspine thornyhead, shortraker, rougheye, and northern rockfishes is scheduled to be published in Vol. 46, nos. 1-3, p 299-312, of Fisheries Research due out in May. This is the publication of proceedings from the Fish Otolith Research and Application symposium that was held in Bergen, Norway, in June 1998.

Still continuing is a study with the NMML to apply radiometric ageing to gray and bowhead whales. Results from these studies suggest that the method may possibly be applicable to gray whales, but not bowhead whales. The problem is excess lead found in the whale bullae.

Nancy Roberson is continuing work on her thesis concerning the ageing of Pacific cod. She has developed preparations which show otolith growth patterns well, and is now focusing on ageing samples from strong year-classes, and the ageing of otoliths from tagged Pacific cod.

Peter Risse left to join the Observer Program, and we hired Tim Price, who recently graduated from Oregon State University majoring in Fisheries Science.

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

Resource Ecology and Ecosystem Modeling - REFM

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 1999, we collected samples during bottom trawl surveys of the Gulf of Alaska and the eastern Bering Sea shelves and the upper continental slope off Washington, Oregon and California. Observers collected stomach samples during fishery operations from the eastern Bering Sea and the Gulf of Alaska. Samples were also collected during the Alaska Department of Fish and Game seasonal bottom trawl survey of the Kodiak shelf. In total, 10,812 stomachs were collected from the eastern Bering Sea, 4,639 from the Gulf of Alaska and Aleutian Islands, and 1,010 from the west coast region. Laboratory

analysis was conducted on 4,398 fish stomachs from the Bering Sea, 3,495 from the Gulf of Alaska and Aleutian Islands, and 729 from the west coast regions.

Multispecies, food web, 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 Alaska Fisheries Science Center (AFSC) web site at http://www.refm.noaa.gov/reem/

Ecosystem Considerations in Fisheries Management: Linking Ecosystem Management Goals with Ecosystem Research

The ICES/SCAR international symposium on Ecosystem Effects of Fishing held March 16-19, 1999 in Montpellier, France provided an opportunity to present a poster describing the following proposal regarding linking ecosystem management goals and ecosystem research. This year we will begin to implement a revision of the Ecosystem Considerations document that provides information to the groundfish plan teams of the North Pacific Fishery Management Council. The revision will expand and standardize some of the content of the Ecosystems Consideration Chapter to more clearly highlight the status of ecosystem-based management efforts and the status and trends of various parts of the ecosystem. These changes and additions would accomplish several goals:

1) track ecosystem management efforts and their efficacy,
2) track changes in the ecosystem that are not easily incorporated into single-species assessments,
3) bring results from ecosystem research efforts to the attention of stock assessment scientists and fishery managers,
4) provide a stronger link between ecosystem research at AFSC (and elsewhere) and fishery management.

As fishery management organizations make progress in incorporating ecosystem-oriented thinking into management, there is a need to more clearly define the ecosystem-oriented management goals of the organization and the tools available to managers to attain those goals. Parallel to this must be an expansion of the scientific advice provided to management beyond traditional single-species stock assessment advice. There is a broad spectrum of ecosystem research currently being conducted that can provide useful advice to managers in this regard including GLOBEC and GLOBEC-like research efforts, habitat research, ongoing trophic interactions work, and long-term monitoring of non-commercial species. Although the ultimate goal is to have quantitative predictions from this research to guide management, these efforts already serve as indicators of ecosystem status and trends. These indicators can provide an early warning system for managers, signaling human or climate-induced changes that may warrant management action. They can also serve to track the success of previous ecosystem-oriented management efforts. The North Pacific Fishery Management Council (NPFMC) has started to include some of this ecosystem research information in an ecosystem considerations document that accompanies the traditional stock assessment reports. The expansion of this document will include ecosystem status and trend information and link management actions with ecosystem observations.

The North Pacific Fishery Management Council has explicitly stated the following ecosystem management goals:

1. Maintain **biodiversity** consistent with natural evolutionary and ecological processes, including dynamic change and variability.
2. Maintain and restore **habitats** essential for fish and their prey.
3. Maintain system **sustainability** and sustainable yields for human consumption and non-extractive uses.
4. Maintain the concept that **humans** are components of the ecosystem.

The new ecosystem considerations document will contain two classes of ecosystem indicators: ecosystem management indicators and ecosystem status indicators. The ecosystem management indicators will measure performance towards meeting the stated ecosystem management goals. These indices will have the advantages of providing early signals of direct human effects on ecosystem components that might warrant management intervention and will provide evidence of the efficacy of previous management actions, such as the efficacy of the Bering Sea bottom trawl closure areas in increasing diversity of benthic fauna. Ecosystem status indicators will provide measures of ecosystem status and trends and serve the dual purposes of 1) bringing the results of ecosystem research efforts to the attention of stock assessment scientists and fishery managers (which will provide stronger links between ecosystem research and fishery management), and 2) bringing together many, diverse research efforts into one document, which will spur new understanding of the connections between ecosystem components and the possible role that climate, humans, or both may have on the system..

Diet Overlap of Some West Coast Groundfish

The stomach contents of several species of groundfish were collected off California, Oregon, Washington and British Columbia during standard NMFS surveys in 1989, 1991 and 1992. Our index of diet overlap was taken as the amount of overlap in the weight composition of the stomach contents. The species of groundfish sampled in this study fell into three major categories. Pacific whiting, arrowtooth flounder and juvenile sablefish consumed mostly euphausiids and other euphausiid consumers. Adult sablefish, shortspine thornyhead , longspine thornyhead, Pacific grenadier and giant grenadier were omnivorous, preying on a wide variety of fishes, crustaceans and other invertebrates, and scavenging on offal. Most of the prey were benthic or epibenthic. Two small mouthed flatfishes, Dover sole and deepsea sole , consumed mainly polychaete worms and brittle stars. Spatial trends in the main prey categories consumed by these west coast groundfish are also illustrated in this report.

Diets of Pacific and Giant Grenadier

In a collaborative investigation with Scripps Institution of Oceanography and the RACE Division, the feeding habits of Pacific grenadier and giant grenadier from the continental slope off Washington, Oregon and California were analyzed. A total of 497 Pacific grenadier and 617 giant grenadier were used in this analysis. We found an ontogenetic shift in the diet of Pacific grenadier from benthic epifauna and infauna (amphipods, cumaceans and polychaetes) to nekton and scavenged material (*Gnathophausia* spp., squid and fish). We found a decrease in squid and an increase in midwater fishes and scavenged material in the diet with increasing size of the giant grenadier examined. These shifts were attributed primarily to increasing mouth size and locomotory ability. Significant differences were found between the diets of Pacific and giant grenadier where they co-occur, indicating some degree of niche separation between these two

species.

Winter Feeding Habits of Pacific Whiting

In January 1997, 226 stomach samples from Pacific whiting were collected during a spawning survey off southern California. Tows were made in midwater at depths of 165-400 m over bottom depths of 750-1800 m. The gonads of Pacific whiting were categorized by their stage of development based on characteristics of the whole organ. In this study, 80% of the stomachs were empty and 20% contained prey items. In stomachs that contained food, fishes dominated the weight composition (88%) and numerical composition (52%) of the diet, and had a high frequency of occurrence (60%). All of the fish were myctophids (lanternfishes) except for one incidence of cannibalism. Myctophids have been found in other studies but not as the dominant prey. The high percentage of empty stomachs was found in all reproductive stages including immature Pacific whiting. We believe our results reflect a lack of other prey in the study area due to seasonal and geographical influences.

Diets of the Groundfishes in the Gulf of Alaska in 1990, 1993, and 1996

A total of 13,928 stomachs from 13 species were analyzed to describe the food habits of the major groundfish species in the Gulf of Alaska in 1990, 1993, and 1996. The analysis emphasized predation on commercially important fish, crab, and shrimp.

Arrowtooth flounder, Pacific halibut, sablefish, Pacific cod, and pollock are the main predators that consume fish. The main predators that feed on Tanner crabs are Pacific halibut and Pacific cod. Pollock, shortspine thornyhead, shortraker rockfish, flathead sole, and rougheye rockfish are the main consumers of pandalid shrimp. Pacific ocean perch, northern rockfish, dusky rockfish, and Atka mackerel did not have too much impact on the commercially important species in the Gulf of Alaska since they feed mainly on euphausiids and calanoid copepods. Pollock were the dominant prey fish every year and were consumed mainly by arrowtooth flounder, Pacific halibut, sablefish, and Pacific cod. Pollock cannibalism, which accounted for only 2% in 1990 and 1% in 1993, but increased to 10% in 1996 of the total stomach contents weights, were not an important phenomenon in the Gulf of Alaska compared with the Bering Sea. Other forage fish, Pacific herring, capelin, eulachon, Pacific sand lance, and Atka mackerel were the next most important prey fishes.

A significant finding in this document is the predation on pandalid shrimp, capelin, and pollock. In 1990 and 1993, the percentages of the pandalid shrimp consumed by pollock, Pacific cod, arrowtooth flounder, and sablefish were high (more than 10% by weight). However, in 1996, only Pacific cod still maintained 11% of pandalid shrimp in their diet. And the percentages of pandalid shrimp in other predators declined dramatically to less than 10%. Based on this study, it seems that there were strong predator-prey relationships between the groundfish species and pandalid shrimp. A similar trend was found in the consumption of capelin. A relatively large amount of capelin were consumed in 1990, and then declined in 1993 and 1996 by most species. However, during this period, the consumption of pollock increased dramatically in 1996 for most of the species.

Sleeper Shark Diet in the Gulf of Alaska

In response to concerns about the possible linkage between increasing sleeper shark populations and the decline in Steller sea lions, a study was performed to examine the diet of sleeper sharks in the Gulf of Alaska to determine if there was evidence of predation on juvenile Steller sea lions. The stomach contents were collected from 13 sleeper sharks collected June-

August, 1996 from longline and bottom trawl vessels fishing at bottom depths of 86-267 m. The sleeper sharks collected during this study were of intermediate size (218-295 cm total length) and they were collected in areas close to Steller sea lion rookeries and haulouts. The stomach contents consisted primarily of bottom-dwelling fish and invertebrates such as arrowtooth flounder and octopus. Fish processing offal also contributed largely to the diet. There was no evidence of predation on juvenile Steller sea lions. The sleeper sharks appeared to primarily feed primarily on benthic prey, likely encountered on or near the ocean bottom.

Multispecies Forecasting of the Effects of Fishing

For several years, the groundfish plan teams have expressed specific ecosystem concerns with regard to the effects of fishing on species composition. In particular, the plan teams have noted that large differences exist in the harvest rates of groundfish species off Alaska. Some groundfish (such as pollock, cod, sablefish, and rockfish) are harvested at or close to their F_{ABC} levels, while other species (such as flatfish) are harvested at substantially lower levels. The plan team has requested analysis of the long-term implications of disproportionate harvest rates.

In order to address this concern, we have used results from a multispecies virtual population analysis (MSVPA) model for the eastern Bering Sea, which has been updated to reflect the information from the 1998 stock assessments. The outputs from the MSVPA model have been used to produce the following forecast of the long-term multispecies effects of harvesting groundfish.

A total of three deterministic MSFOR models and three single species models were set up to analyze the equilibrium dynamics of the system under two regimes of fishing mortality. The first level known as the 'reference *F*' was calculated as the average of the last three years (1996-1998) of the fishing mortality estimates from the MSVPA models. The second level of future *F* was defined as the level of fishing mortality producing the Acceptable Biological Catch (F_{ABC}) in the 1998 stock assessments. The values for the F_{ABC} and the selectivity patterns for each species were taken from the 1998 SAFE report. Results from MSFOR and the single species forecasts predict almost the same trends for the relative changes of yield biomass, total biomass and spawning biomass under the F_{ABC} regime. However two species are the exception. Rock sole and Pacific herring seem to respond slightly differently because of predation interactions. The F_{ABC} regime is characterized by a decrease for fishing mortality under the F_{ABC} regime ($F_{ABC} < F_{ref}$) for walleye pollock. For the rest of the species F_{ABC} is larger than F_{ref}, except for herring that is managed with a 20% constant harvest rate. This trend is reflected in the results for the relative percentage change of yield that is characterized by a decrease in the long-term yield of pollock and herring when F_{ABC} is implemented in the model compared to the yield obtained under the F_{ref} regime. The opposite case is found for the rest of the species, which showed increases in the long-term yield. . When F_{ABC} is implemented, the biomass and spawning biomass of pollock increases due to a reduction of fishing mortality to the F_{ABC} level. Total biomass and spawning biomass decreased for cod, yellowfin sole, Greenland turbot and rock sole. This decrease in biomass and spawning biomass results from the increase of fishing mortality under the F_{ABC} regime. Although a simple assumption of recruitment was implemented, the MSFOR model provided valuable information on the possible consequences in the long-term indicators analyzed. In the future, more realistic assumptions on recruitment will be added to the model.

NCEAS Workshop Summary

A workshop entitled "Ecological Implications of Alternative Fishing Strategies for Apex

Predators" at the National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara, California was attended. The focus of this meeting was threefold:

(1) Predator/prey dynamic models of multi-species fisheries were compared using the modeling packages ECOPATH and ECOSIM. Carl Walters, the developer of ECOSIM, took feedback on ECOSIM's functionality, and alternate modeling procedures were discussed. One primary distinction between ECOSIM and other non-spatial predator/prey dynamic models is the concept of the "foraging area," a mathematical approximation of heterogeneous environmental variables which requires a minimal set of parameters. Methods of estimating parameter values were compared, based on the results of Eastern Bering Sea models constructed for the 1950s and 1980s. The importance of the predator/prey relationships in determining stock/recruitment parameters was also discussed. A methodology was developed for comparing ECOSIM results with age-structured population models.

(2) Preparations were made to present ECOSIM model results of the Eastern Tropical Pacific tuna fishery to the annual IATTC Council Meeting in April 2000. The focus will be on using ECOSIM to assess issues of bycatch and gear type within the fishery, in a manner which includes cascading predator/prey interactions resulting from changes in fishing pressure.

(3) Environmental forcing of primary production, using a 100-year ENSO time series, was applied to modeled ecosystems. Preliminary comparisons were made of the changing frequencies of predator/prey interaction at different levels of fishing pressure. The use of ecosystem indicators such as throughput, respiration, or variance were compared and discussed.

Based on these results, work is continuing on the parameterization of two new ECOPATH food web models of the Eastern Bering Sea, covering the 1980s and the 1990s. After model parameterization, the parameter estimation procedure will determine if observed changes in predator/prey relationships require changes in foraging modes, predator preference, or the habitat of predators to remain mathematically consistent.

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

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 Steller 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 regional management councils 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 1999, no foreign vessels were allowed to catch or process fish in the U.S. EEZ along the west coast and Alaska. The Observer Program trained and deployed 627 observers to vessels fishing off Alaska, and 14 observers to vessels fishing off the Washington-Oregon-California coast. The Program was 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 were provided to the Alaska and Northwest Regional Offices to assist in management decisions regarding the catches of groundfish and prohibited species. Data were also collected regarding the operations of the groundfish fishery.

CDQ and AFA Fisheries

Implementation of an expanded Community Development Quota (CDQ) program and implementation of provisions of the recently enacted American Fisheries Act (AFA) continued during 1999. The CDQ program was developed for the purpose of allocating fishery resources to eligible Western Alaska communities to provide the means for starting or supporting commercial fishery activities that would result in regionally based commercial fisheries or related businesses. CDQ was initiated in 1992 with pollock and expanded to include fixed gear halibut and sablefish in 1995. In 1998, it was further expanded to include multiple species of groundfish and crab (MSCDQ). In 1999, NMFS was responsible for monitoring the groundfish (including pollock and

sablefish) and halibut CDQs and the State of Alaska was responsible for monitoring the crab CDQs.

The AFA, enacted by Congress in late 1998, made changes to the pollock fishery in the Bering Sea and Aleutian Islands. These changes included reallocation of fish among industry segments, provided for the formation of fishing cooperatives, and increased observer coverage levels on some components of the fleet. The offshore component of the fleet has organized a fishing cooperative this year and has been receiving increased, mandatory observer coverage. More recently, the Observer Program has been involved in implementation of aspects of the AFA related to shoreside pollock. The shoreside component has proven to be more complex then offshore and will involve possible NMFS regulatory actions and a changing role for the observer.

MSCDQ and AFA catch accounting for offshore processors is based entirely on data collected by observers and, unlike the open access fisheries, where observer data is used to manage a fleet wide quota, industry participants in the MSCDQ and AFA fisheries require individual accounting of fish harvested in each haul or set. This change in expectations placed on observers, their data, and the Observer Program in general, has required much Observer Program staff effort in the development of special selection criteria and training requirements for observers, development of new sampling strategies and regulations to enhance the observer's working environment, as well as changes to the data collection and data management software systems.

Observer Program Review

An extensive, independent review of the Observer Program began in late 1999. The review is being carried out by Marine Resources Assessment Group (MRAG) Americas, Inc. MRAG is an independent consulting firm which provides professional advice and services for the management of marine fisheries throughout the world. The purpose of this review is to provide recommendations for changes in Program operations and organization which might improve the Program's ability to meet its mission and goals. Their final report is due sometime next year.

New Observer Contractor

A new observer contractor was certified by NMFS in late December 1999, to provide observer services for the North Pacific groundfish fisheries. The company's name is TechSea International. The company's principles are Dr. Harry G. Benson and Mr. Jacob I. Chabinka. Dr. Benson operates SeaWatch Inc., a Canadian company that has been providing observer services to the government of Canada since 1981. Mr. Chabinka also has experience providing observer services, his company, JAVITECH, Ltd., has been contracted to operate the Scotia-Fundy Observer Program on the Canadian east coast from 1995 to 2000. TechSea has established an office in Seattle and has hired an office manager, Mr. James Greiner. He can be reached at 206-285-1408.

For further information or if you have questions about the North Pacific Groundfish Observer Program please contact Dr. Daniel Ito, (206) 526-4194.

Socioeconomic Assessment Program - REFM

From May 1999 through April 2000, the Socioeconomic Assessments Program was actively involved in providing economic information used in the evaluation of management

measures being considered by the Pacific and North Pacific Fishery Management Councils. Center economists served on the GOA and West Coast groundfish plan teams and on both NPFMC and PFMC technical work groups and contributed significantly to, and in several cases had the lead for, the analyses and review of the following fishery management actions: (1) sea lion protection in the BSAI pollock and Atka mackerel fisheries and the GOA pollock fishery, (2) economic and social data collection for the BSAI and GOA groundfish fisheries, (3) allocation of Pacific halibut between the commercial fishery and the charter boat sector of the recreational fishery, (4) American Fisheries Act, (5) industry-funded buyback for PFMC groundfish fisheries, (6) PFMC rebuilding plans, (7) stacking of PFMC groundfish permits (8) PFMC groundfish trip limits, and (9) management options for the 3-tiered PFMC groundfish fishery. Three other activities in support of the NPFMC were: (1) assisting in planning for the preparation of a programmatic supplemental environmental impact statement for the BSAI and GOA groundfish fisheries; (2) initiating a cost, earnings and employment survey for part of the Alaska groundfish fishery; and (3) preparing an annual report on the economic status of the Alaska groundfish fisheries.

Center economists assisted with NMFS national projects involved with defining and measuring excess fishing capacity and developing guidelines for the economic analysis of fishery management actions. In addition, they provided economic advice, technical review and support both for Saltonstall-Kennedy and Sea Grant research proposals and for the development of the AKFIN system,

Center economists prepared publications on fishing capacity, the location choice decision of fishermen, marine protected reserves, valuing recreational fisheries, behavioral and modeling of Alaska groundfish fisheries.

Dr. Jim Hastie accepted a position at the Northwest Fisheries Science Center. Jim had been a member of the Socioeconomic Assessments Program since 1987 and in recent years he was involved principally in various aspects of managing the west coast groundfish fishery. His new position is dedicated to addressing management and research issues in that fishery and to developing a west coast economic program for groundfish within NMFS.

For further information contact Dr. Joe Terry (206) 526-4253.

C. By species, by agency

1. Pacific cod

b. Stock Assessment

BERING SEA/ALEUTIANS

The present assessment is a straightforward update of last year's assessment, incorporating new catch and survey information. This year's EBS bottom trawl survey resulted in a biomass estimate of 583,000 t, a 9% increase relative to last year's estimate. Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 379,000 t, 0.30, and 0.35, respectively. Fishing at a rate of 0.28 is

projected to result in a 2000 spawning biomass of 357,000 t, and solves the equation for the maximum permissible value of F_{ABC} under tier 3. Because projected biomass for 2000 is less than $B_{40\%}$, Pacific cod qualify for management under sub-tier Ab@ of tier 3. Fishing at an instantaneous rate of 0.28 is projected to result in a 2000 catch of 206,000 t, which is the maximum permissible ABC under Amendment 56. However, the chapter authors' recommends to set 2000 ABC at 193,000 t, about 6% below the maximum permissible level. This recommendation is based on a risk-averse optimization procedure which considers uncertainty in the estimates of the survey catchability coefficient and the natural mortality rate in the computation of an $F_{40\%}$ harvest level. This 6% reduction from the maximum permissible ABC is justified not only on the basis of these decision-theoretic concerns, but also because estimated spawning biomass from the model has declined continuously since 1985 and because three of the last four year classes (assessed at age 3) appear to have been well below average. A 2000 catch of 193,000 t would represent an increase of 9% over the 1999 ABC of 177,000 t, matching the 9% increase in the trawl survey biomass estimate. However, the assessment model projects a 2001 ABC (using the same relative harvest rate) of 171,000 t with a continuing decline through 2003 (expected ABC = 138,000 t), meaning that the increase for 2000 is expected to be short-lived. A 2000 catch of 193,000 t corresponds to a fishing mortality rate of 0.26, below the value of 0.28 which constitutes the upper limit on F_{ABC} under tier 3b.

The recommended OFL was determined from the tier 3b formula, where fishing at a rate of 0.33 gives a 2000 catch of 240,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

GULF OF ALASKA

Since last year=s assessment, 1) size composition data from the 1998 and January-August 1999 commercial fisheries, 2) size composition data from the 1999 GOA bottom trawl survey, 3) the biomass estimate from the 1999 GOA bottom trawl survey, and 4) weight-at-length data from recent GOA bottom trawl surveys have been incorporated. The 1999 bottom trawl survey biomass estimate of 305,823 t was down about 43% from the 1996 survey estimate.

As in past assessments, the assessment author conducted a Bayesian analysis, providing the joint prior distributions and calculating the joint likelihoods of M and Q, resulting in the posterior distributions for M and Q and the yield that would result from an $F_{40\%}$ harvest strategy. The assessment focused on 3 models. Model 1 sets M and Q equal to estimates obtained independently of the assessment models, estimates which are used as the means of the marginal distributions of the prior distributions of the two parameters. Model 2 sets M and Q equal to their maximum likelihood estimates, and Model 3 sets M and Q equal to the mean of their marginal posterior distributions. To generate a set of reference estimates of historic biomass trends, target and limit harvest rates, and biomass projections, the author chose Model 1. Maximum permissible values of ABC and OFL under Tier 3a are the $F_{40\%}$ (=0.38) and $F_{35\%}$ (=0.46) yields from Model 1, 86,000 and 102,000 t, respectively. The age 3+ biomass under Model 1 for the year 2000 is 567,000 t. The author noted that the historic trend of catch and age 3+ biomass shows a pattern in exploitation rate over time where the rate has or exceeded the average for every year after 1989, while the estimated values fall below average for every year prior to 1990.

The author=s ABC recommendation of 76,400 t is the geometric mean of the posterior distribution of 2000 catch obtained under an $F_{40\%}$ harvest strategy and is equivalent to an F=0.33. The projection estimates the stock to be decreasing, however since 76,400 t does not represent

an increase over the past year=s ABC, it was accepted as the recommended ABC for the year 2000.

The author notes in his report that if the TAC is to be distributed between regulatory areas in proportion to the biomass estimates from the most recent trawl survey, the proportions are: Western- 36% , Central-57%, and Eastern-7%, which would result in 27,500 t, 43,550 t, and 5,350 t, respectively, for a 76,400 t gulfwide TAC.

For further information, contact Dr. Grant Thompson at (206) 526-4232.

3. Shelf Rockfish

a. Research

Distribution and Habitat of Rockfish in Nearshore Waters of Southeast Alaska

Scientists in the ABL Habitat Program completed the second year of a three-year study to assess the distribution and habitat of rockfish in nearshore waters of Southeast (SE) Alaska. Sampling methods included use of a beach seine to capture fish in shallow (<10 m deep), vegetated habitats (e.g., eelgrass meadows, understory kelps) and a remotely operated vehicle (ROV) to record *in situ* observations of rockfish in deeper water (10-90 m) habitats such as vertical bedrock walls and complex bottoms of boulders or broken rock. To date, 74 seine hauls and 150 ROV dives have been completed throughout SE Alaska. Of the approximately 32 species of rockfish known to occur in the Gulf of Alaska, 12 species were captured or observed in nearshore waters of SE Alaska. Shallow, vegetated habitats were frequented by adult black and copper rockfish and unidentified juvenile rockfish. Tagging studies showed that juvenile (age $\geq$1) copper rockfish moved into shallow, vegetated habitats in early summer and remained there for up to four months. Young-of-the-year rockfish appeared in nearshore, vegetated habitats in August. In bedrock wall and complex bottom habitats with numerous ledges, holes, and crevices, rockfish observed with the ROV included adult black, canary, china, copper, dusky, Puget Sound, quillback, rosethorn, silvergray, tiger, yelloweye, yellowtail, and unidentified juvenile rockfish. Rockfish were absent in flat, soft-bottom basins with no vegetation and little cover. Quillback rockfish were observed at more locations (16 of 24) in SE Alaska than any other rockfish species, whereas china rockfish were seen at only 1 location, the fewest of any rockfish species. Studies in 2000 will focus on sites in more inside waters of SE Alaska to gain a better geographic perspective on the distribution and habitat of rockfish.

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

b. Stock Assessment

GULF OF ALASKA

Pelagic Shelf Rockfish

The pelagic shelf rockfish assemblage is comprised of three species 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 1980s. 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. Taxonomic work is in progress to determine if these two forms are separate species, which they appear to be.

Similar to previous years, ABC for the assemblage in 2000 is calculated using biomass estimates based on trawl survey data. Gulfwide exploitable biomass, 66,443 t, is based on the

average of the biomasses estimated for the assemblage in the three most recent trawl surveys of this region (those in 1993, 1996, and 1999). Almost all this biomass comes from dusky rockfish. Applying an *F=M* strategy to this biomass, in which the annual exploitation rate is set equal to the estimated rate of natural mortality for dusky rockfish (0.09), yields a Gulfwide ABC of 5,980 t for 2000.

For more information, contact David Clausen at (907) 789-6049 or Jon Heifetz at (907) 789-6054.

4. Slope Rockfish

a. Research

GULF OF ALASKA

Adaptive Cluster Sampling of Slope Rockfish

A cooperative study between the Auke Bay Laboratory (ABL) and the Juneau Center for Fisheries and Ocean Science (JCFOS) of the University of Alaska Fairbanks (UAF) was conducted 13-29 June 1999 aboard the chartered factory trawler *Unimak* in the Gulf of Alaska. This was the second year of a two-year study to improve survey techniques for assessing abundance of slope rockfish in the Gulf of Alaska. Partial funding for both years was provided by the Sea Grant - NOAA Partnership Program. The first part of the study was conducted in 1998, and also used the F/T *Unimak* (at that time named the *Unimak Enterprise*). The study focused on three commercially important species of slope rockfish, Pacific ocean perch (POP), shortraker rockfish (SR), and rougheye rockfish (RE).

The purpose of the study both years was to evaluate a new trawl survey design, adaptive cluster sampling, that may lead to improved abundance estimates for slope rockfish. The present trawl surveys use a stratified random methodology to select their pattern of trawl stations, which may not be appropriate for sampling populations with a clustered distribution, such as that observed for many rockfish species. In adaptive cluster sampling, random sampling is initially used to locate concentrations of the targeted species, and is then followed by intensive systematic sampling in the vicinity of the concentrations. The two working hypotheses of the study were that adaptive sampling (1) would result in more precise abundance estimates for POP than would simple random sampling, and (2) be more applicable for POP than for SR/RE, because POP are thought to be more aggregated in their distribution.

The 1999 portion of the study followed up on results of the 1998 adaptive sampling experiment to better determine the potential of this technique for improving abundance estimates of slope rockfish. Specific objectives in 1999 were to: 1) sample a different, larger study area than in 1998; 2) not stratify the study area (the 1998 study area had been stratified, and this stratification appeared to substantially affect the 1998 results); and 3) investigate three alternative strategies for adaptive sampling methods different than those used in 1998. The 1999 study area was located in the eastern Gulf of Alaska in the vicinity of the "W" Grounds and Yakutat Valley between 140° and 144° W longitude. As in the 1998 experiment, a Poly Nor'Eastern trawl equipped with tire gear on the footrope was used to facilitate trawling over rough bottoms. A

total of 171 hauls was completed during the 1999 experiment. To defray chartering costs and eliminate waste, the *Unimak* was allowed to process and sell all fish caught during the charter.

Results of the 1999 experiment substantiated the first hypothesis because adaptive sampling resulted in more precise abundance estimates for POP. In particular, the modifications to the experimental design in 1999 discussed in the previous paragraph greatly improved the adaptive sampling results when compared with the 1998 results. The second hypothesis was also confirmed, as adaptive sampling did not prove to be more effective for SR/RE. Thus, incorporation of adaptive cluster sampling into future POP trawl survey designs would very likely yield improved abundance estimates for this species.

For more information, contact Jon Heifetz at (907) 789-6054 or Dave Clausen (907) 789-6049.

Northern Rockfish Commercial Fishery, Distribution, and Biology

The northern rockfish is the second most abundant rockfish in Alaska, and supports a valuable trawl fishery. Little information is available, however, on either the biology of this species or its fishery. To provide a synopsis of information on northern rockfish in the Gulf of Alaska and Aleutian Islands, ABL scientists examined data for northern rockfish from commercial fishery observations in 1990-98 and from NMFS trawl surveys in 1980-99. Most of the commercial catch was taken from a number of relatively small and discrete fishing grounds at depths of 75 to 150 m. These grounds, especially in the Gulf of Alaska, are on shallow rises or banks located on the outer continental shelf, and often are surrounded by deeper water. One fishing ground, the "Snakehead" south of Kodiak Island, accounted for 46% of the total northern rockfish catch in the Gulf of Alaska. Most of the catch in the Aleutian Islands was taken as by-catch in the Atka mackerel fishery, whereas most in the Gulf of Alaska came from direct targeting on northern rockfish. About 80-90% of the northern rockfish caught in the Aleutian Islands was discarded, whereas only 20% was discarded in the Gulf of Alaska. Northern rockfish were consistently smaller in the Aleutian Islands. Analysis of the survey data revealed generally similar patterns of distribution and size as those seen in the fishery, although some of the fishing grounds did not stand out as areas of particular abundance in the surveys. A comparison of age samples in each region showed that Aleutian Islands fish grew significantly slower and reached a smaller maximum size than those in the Gulf of Alaska. Similar to many other rockfish, the surveys showed juvenile northern rockfish tend to reside in more inshore, shallow areas than adults. Few juveniles were caught, however. Survey size composition data indicated that strong recruitment appears to be a relatively infrequent event. In most years, overall ratio of males to females was nearly 1:1.

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

Species Identification of Rockfish Larvae

In late spring and early summer, rockfish larvae are among the most abundant fish larvae in the eastern Gulf of Alaska. Also, they are the most difficult to identify to species level. ABL scientists, in cooperation with Dr. Anthony Gharrett and Andrew Gray of the University of Alaska

Fairbanks, continue working on identification of preflexion rockfish larvae using digital camera records of pigment patterns and mitochondrial DNA (mtDNA) techniques to confirm species identifications. Experiments in May 1996 showed that single preflexion larvae could be identified using mtDNA at smaller sizes than possible with allozyme techniques. In 1997, 1998, and 1999, preflexion and postflexion larvae were subjected to mtDNA analysis. Although the sample sizes are small (about 200 m^3 of water yields 1 to 30 larvae), up to eight species have been found in a given sampling area and up to six species of rockfish larvae in a single sample. The study has identified fourteen species of rockfish: *Sebastes aleutianus, S. alutus, S. auriculatus, S. babcocki, S. borealis, S. brevispinus, S. caurinus, S. ciliatus, S. elongatus, S. maliger, S. proriger, S. ruberrimus, S. variegatus,* and *S. zacentrus*. As the data base grows, plans are to describe the variability of larval pigment patterns within a species and how pigment patterns change with growth. In 2000, the study will be expanded to include postflexion larvae and additional species.

For more information, contact Bruce Wing at (907) 789-6043.

WEST COAST

Rockfish Maturity (Histological Evaluation)

Frank Shaw recently completed research on the maturation of rosethorn, redstripe, sharpchin, and greenstriped rockfish for a MS degree at the UW. His thesis was entitled "Life history traits of four species of rockfish (Genus *Sebastes*)". He presented the histological portion of that work at the Western Groundfish Conference in Sitka in April and is also preparing a manuscript for publication in a refereed journal.

For more information, contact Frank Shaw, (206) 526-4120.

b. Stock Assessment

BERING SEA AND ALEUTIAN ISLANDS

Rockfish

The POP complex consists of true POP (*Sebastes alutus*) and four other red rockfish species (northern rockfish, rougheye rockfish, sharpchin rockfish, and shortraker rockfish). Prior to 1991, the complex was managed as a unit in each of the two management areas. Since 1991, however, the Council has managed *S. alutus* separately from the other species in both areas, and has also split out rougheye and shortraker in the Aleutians. This was done to avoid excessive catches of the less abundant members of the complex, particularly shortraker and rougheye. Beginning in 1996, the ABC and TAC for true POP have been subdivided within the AI area, based on an average of the biomass estimates from the two most recent trawl surveys: Eastern subarea (541) 25%, Central subarea (542) 25%, and Western subarea (543) 50%.

True POP, Eastern Bering Sea

The present assessment is a straightforward update of last year's assessment, incorporating

new catch information. The POP spawning population biomass is estimated to be slightly below it=s long-term average after having rebounded from low levels in the mid to late 1970s. Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 26,200 t, 0.057, and 0.069, respectively. Projected spawning biomass for 2000 is 24,900 t, placing true POP in the EBS in sub-tier "b" of Tier 3. The maximum F_{ABC} value allowed under Tier 3b is computed as follows:

$$F_{ABC} \le F_{40\%} \times (B_{2000}/B_{40\%} - 0.05)/(1-0.05) = 0.057 \times (24{,}900/26{,}200 - 0.05)/0.95 = 0.054$$

Projected harvesting at a fishing mortality rate of 0.054 gives a 2000 catch of 2,600 t, which is the recommended ABC (last year=s ABC was set using a lower fishing mortality rate, 0.040, in part because last year=s $B_{40\%}$ estimate of 34,400 t was higher than this year=s estimate of 26,200 t).

The OFL fishing mortality rate is computed under Tier 3b as follows:

$$F_{OFL} = F_{35\%} \times (B_{2000}/B_{40\%} - 0.05)/(1-0.05) = 0.069 \times (24{,}900/26{,}200 - 0.05)/0.95 = 0.065$$

Projected harvesting at a fishing mortality rate of 0.065 gives a 2000 catch of 3,100 t, which is the recommended OFL. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

True POP, Aleutians

The present assessment is a straightforward update of last year's assessment, incorporating new catch information and age composition data. POP were overfished from high abundance levels in the 1960s (1.2 million t) to low levels in the late 1970s (105,000 t). The population biomass has since increased to 470,000 t as estimated from the stock assessment model. The female spawning biomass is estimated to be slightly lower than it=s long-term average.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 100,000 t, 0.072, and 0.085, respectively. Projected spawning biomass for 2000 is 97,800 t, placing true POP in the Aleutians in sub-tier "b" of Tier 3. The maximum F_{ABC} value allowed under Tier 3b is computed as follows:

$$F_{ABC} \le F_{40\%} \times (B_{2000}/B_{40\%} - 0.05)/(1-0.05) = 0.072 \times (97{,}800/100{,}000 - 0.05)/0.95 = 0.070$$

Projected harvesting at a fishing mortality rate of 0.070 gives a 2000 catch of 12,300 t, which is the recommended ABC (last year=s ABC was set based on Tier 3a, so no adjustment of the $F_{40\%}$ rate was required). The ABC is apportioned among AI subareas based on survey distribution as follows: Western AI = 46.1%, Central AI = 28.5% , and Eastern = 25.4%.

The OFL fishing mortality rate is computed under Tier 3b as follows:

$F_{OFL} = F_{35\%} \times (B_{2000}/B_{40\%} - 0.05)/(1-0.05) = 0.085 \times (97{,}800/100{,}000 - 0.05)/0.95 = 0.083$
Projected harvesting at a fishing mortality rate of 0.083 gives a 2000 catch of 14,400 t, which is the recommended OFL. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Other Members of the POP Complex, Eastern Bering Sea

The present assessment is slightly modified from last year=s assessment. In the current assessment, biomass was estimated from domestic trawl surveys only (1988-1997). This modification addresses concerns about biomass estimates for northern rockfish that included results from two exceptionally large tows of northern rockfish from the 1986 Aleutian trawl survey (in the small part of the EBS covered by that survey). These tows were responsible for approximately 94% of the northern rockfish biomass estimate in that year. Last year, the SSC concluded that biomass estimates produced by eliminating the 1986 survey estimate represented the best estimate of northern rockfish biomass in the EBS. The change provided in this assessment addresses these concerns, and the surveys conducted from 1988-97 are used to provide better estimates of current biomass.

Last year, the SSC determined that reliable estimates of the natural mortality rate (*M*) existed for the species in this complex, and that non-*alutus* members of the POP complex in the EBS therefore qualified for management under Tier 5 of the BSAI Groundfish FMP. The accepted estimates of *M* for these species in the EBS are as follows: rougheye rockfish--0.025, shortraker rockfish--0.030, and northern rockfish--0.060. The Plan Team recommends setting F_{ABC} at the maximum value allowable under Tier 5, which is 75% of *M*. On a species-specific basis, this translates into the following F_{ABC} values: rougheye rockfish--0.019, shortraker rockfish--0.023, and northern rockfish--0.045. Multiplying these rates by the best estimates of species-specific biomass and summing across species gives a 2000 ABC of 194 t. The assessment authors recommend separate ABCs for the SR/RE and NO/SC complexes in the Bering Sea, as is done in the Aleutian Islands. Their reasons are as follow: 1) these species occupy different depth ranges and can thus be differentially targeted, 2) there is an economic incentive to target SR/RE because they command a higher price, and 3) a combined quota could allow for higher fishing mortality of the SR/RE component than is desired. No catch information by species was provided to evaluate the biological and management implications, of this recommendation, however. Therefore, it was recommended continuing with a combined 2000 ABC for EBS Aother red rockfish@.

The OFL was determined from the Tier 5 formula, where setting $F_{OFL}=M$ for each species gives a combined 2000 OFL of 259 t. As a Tier 5 stock complex, it is not possible to determine whether the EBS Aother red rockfish@ complex is overfished or whether it is approaching an overfished condition.

Sharpchin and Northern Rockfish, Aleutians

Because sharpchin rockfish are found only rarely in the Aleutians, northern rockfish are for all practical purposes the only species in this complex. Traditionally, the biomass estimates from all Aleutian bottom trawl surveys have been averaged over all years to obtain the best estimate of northern rockfish biomass. In the current assessment, however, biomass was estimated from the domestic trawl surveys only (1988-1997). Last year, the SSC determined that a reliable estimate of the natural mortality rate (*M*) existed for this stock, and that northern rockfish in the Aleutians therefore qualified for management under Tier 5 of the BSAI Groundfish

FMP. The accepted estimate of *M* for northern rockfish in the Aleutians is 0.06. The Plan Team recommends setting F_{ABC} at the maximum value allowable under Tier 5, which is 75% of *M*, or 0.045. Multiplying this rate by the best estimate of biomass gives a 2000 ABC of 5,150 t.

The OFL was determined from the Tier 5 formula, where setting $F_{OFL}=M$ gives a 2000 OFL of 6,870 t. As a Tier 5 stock complex, it is not possible to determine whether the AI sharpchin/northern complex is overfished or whether it is approaching an overfished condition.

Shortraker and Rougheye Rockfish, Aleutians

Traditionally, the biomass estimates from all Aleutian bottom trawl surveys have been averaged over all years to obtain the best estimate of shortraker and rougheye rockfish biomass. In the current assessment, however, biomass was estimated from the domestic trawl surveys only (1988-1997). Last year, the SSC determined that reliable estimates of the natural mortality rate (*M*) existed for the species in this complex, and that shortraker and rougheye rockfish in the Aleutians therefore qualified for management under Tier 5 of the BSAI Groundfish FMP. The accepted estimates of *M* for these species in the Aleutians are as follows: rougheye rockfish--0.025 and shortraker rockfish--0.030. The Plan Team recommended setting F_{ABC} at the maximum value allowable under Tier 5, which is 75% of *M*. On a species-specific basis, this translates into the following F_{ABC} values: rougheye rockfish-- 0.019 and shortraker rockfish--0.023. Multiplying these rates by the best estimates of species-specific biomass and summing across species gives a 2000 ABC of 885 t.

The OFL was determined from the Tier 5 formula, where setting $F_{OFL}=M$ for each species gives a combined 2000 OFL of 1,180 t. As a Tier 5 stock complex, it is not possible to determine whether the AI shortraker/rougheye complex is overfished or whether it is approaching an overfished condition.

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

GULF OF ALASKA

Slope rockfish are defined as those species of *Sebastes* that, as adults, inhabit waters of the continental slope and outer continental shelf, generally in depths greater than 150-200 m. Twenty-one species of rockfish are classified into the slope assemblage, the most abundant of which are Pacific ocean perch, and northern, rougheye, redstripe, sharpchin, shortraker, silvergray, and harlequin rockfish. Until recently, the stock abundance of slope rockfish, especially Pacific ocean perch, was considered to be quite depressed compared to its former abundance in the early 1960s. The most recent trawl surveys of the Gulf of Alaska in 1996 and 1999 showed a substantial increase in biomass of Pacific ocean perch. This increase followed another large increase in biomass seen in 1993, and suggests that current abundance of Pacific ocean perch is much improved in comparison with its formerly depressed condition. The Stock Synthesis Model is applied to Pacific ocean perch. This model incorporates age composition, in addition to using other data such as fishery CPUE and estimated biomass from trawl surveys. Based on the model, the best estimate of exploitable biomass for Pacific ocean perch in the Gulf of Alaska is now 200,310 t, similar to last year's estimate of 243,170 t. Exploitable biomass for all other species in the assemblage is estimated from the average values in the 1993, 1996 and 1999 trawl surveys, and totals 258,760 t. Unlike Pacific ocean perch, survey biomass estimates

for the other species have generally not shown large increases in recent years.

Estimated age compositions of Pacific ocean perch indicate the presence of a strong 1986 year class, especially in the central and western Gulf of Alaska. This age class was first noted in samples from the 1990 triennial survey and verified in the 1993 and 1996 surveys. Past age samples also identified a strong 1976 year class.

To prevent possible over-exploitation of the more desirable species, the slope rockfish assemblage is divided into four subgroups: Pacific ocean perch, shortraker/rougheye rockfish, northern rockfish, and other slope rockfish. Separate ABCs are assigned to each subgroup. Pacific ocean perch are presently managed using an $F_{40\%}$ strategy adjusted for relative spawning biomass. The other subgroups are managed under an $F=M$ strategy, in which the annual exploitation rate is set equal to or less than the rate of natural mortality. The 2000 ABCs are as follows: Pacific ocean perch, 13,020 t; shortraker/rougheye rockfish, 1,730 t; northern rockfish, 5,120 t, and other slope rockfish, 4,900 t.

For more information, contact Jonathan Heifetz at (907) 789-6054, James Ianelli at (206) 526-6510, or David Clausen at (907) 789-6049.

Age-structured Model Applied to Northern Rockfish

In 1999, scientists at ABL applied an age-structured population model to northern rockfish in the Gulf of Alaska (GOA) in order to improve stock assessment of this species. The northern rockfish is one of the most abundant and commercially valuable members of its genus in Alaska waters. Since 1990, northern rockfish has supported a valuable domestic trawl fishery in Alaska. For the Gulf of Alaska region alone recent catch levels have been around 5,000 metric tons (t); gross wholesale value of this fishery was estimated at $4 million in 1995. Previous assessments of GOA northern rockfish, like many other slope rockfish in this region, have relied entirely on biomass estimates provided by NMFS trawl surveys. In the present study, AD Model Builder software was used to construct the age-structured model for northern rockfish. Procedures in the model selected for northern rockfish generally followed those used in a similar model developed for GOA Pacific ocean perch. The model was fit to available GOA catch and size composition data as well as NMFS trawl survey size and age compositions. The model is expected to be used for the determination of northern rockfish stock status for the 2001 fishery.

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

5. Thornyheads

b. Stock assessments

Shortspine thornyheads were assessed using the same model as in the preceding year. The 1999 NMFS survey extended into deeper water thereby covering more of the shortspine thornyhead habitat. The authors treated the 1999 estimate the same as the earlier surveys where deeper areas had been surveyed. The general trend showed an increase in biomass, although the population has been relatively stable since 1970. The author=s recommendation for year 2000

ABC is 2,360 t (based on Tier 3a; F_{ABC} = 0.077). The corresponding overfishing level is 2,830 t F_{OFL}=0.092).

Concerns were expressed concern that the survey estimates showed what appeared to be significant increases in stock abundance yet the model predictions indicate a slight decline. The authors indicated that this might be due to model mis-specification problems related to the assumptions about growth (and the effect this assumption has on natural mortality). Future assessments will evaluate model runs where the 1999 biomass estimate is derived from only shallower tows (as in 1990, 1993, and 1996). This may provide insight on the importance of the deeper stations.

The area specific apportionments give 425, 991, and 944 tons to the Western, Central and Eastern Gulf of Alaska, respectively.

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 1987-99. 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. The eastern Bering Sea, Aleutian Islands region, and Gulf of Alaska were sampled during the cooperative longline survey, but the AFSC longline survey sampled only the Gulf of Alaska until 1996, when biennial sampling of the Aleutian Islands region and eastern Bering Sea was added. The eastern Bering Sea was sampled in 1999. In 1999, 73 stations were sampled in the Gulf of Alaska and 16 stations were sampled in the eastern Bering Sea from 28 May to 5 September. Sixteen kilometers of groundline were set each day, containing 7,200 hooks baited with squid, except in the eastern Bering Sea, where eighteen kilometers and 8,100 hooks were set each day. The survey vessel was the chartered fishing vessel *Ocean Prowler*. Sablefish was the most frequently caught species, followed by giant grenadiers, Pacific cod, arrowtooth flounder, and Pacific halibut. A total of 88,949 sablefish, with an estimated total round weight of 298,146 kg, was taken during the survey.

A total of 3,868 sablefish, 603 shortspine thornyhead, and 188 Greenland turbot were tagged and released during the survey. Length-weight data and otoliths were collected from 2,451 sablefish. Thirty-six surface gillnet sets were also completed to assess the abundance of juvenile sablefish. A very low number of sablefish (28 young-of-the year-and 12 age-1) were caught in the gillnets during the 1999 survey.

Killer whales preying on sablefish and Greenland turbot caught on the gear were observed at seven eastern Bering Sea stations, and may have affected catch rates at these stations.

For more information contact Michael Sigler at (907)789-6037 or Tom Rutecki at (907)789-6051

Sablefish Longline Hook Spacing Experiment

In addition to the sablefish longline survey, a longline hook spacing experiment also was conducted from the chartered fishing vessel *Ocean Prowler* near Yakutat on 25-26 July 1999. The purpose of the experiment was to test an assumption on how to interpret longline fishery catch rates. The fishery catch per skate is assumed to be an index of relative abundance. For example, a 10% difference in catch rate reflects a 10% difference in relative abundance. This assumption would be wrong if increasing the hook spacing increased the fishing power of each hook. Most (about 70%) sablefish longline fishermen currently use 1 meter hook spacing, but this spacing differs between vessels and may change with time. In the hook-spacing experiment, circle hooks (size 13/0) baited with squid were used. Four hook spacings were tested: 0.5, 1, 2, and 4 m. Six sets were competed. Each set contained all hook spacings. For this experiment and an earlier hook spacing experiment conducted in 1986, catch rate per hook increased as hook spacing increased to an asymptote at 4-m spacing.

Catch per hook for 1-m spacing, the most common spacing currently used in the fishery, was about half that for the 4-m spacing. These results imply that analysis of fishery catch rates should be standardized by longline set to account for differences in hook spacing.

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

ABL Sablefish Tag Recovery Program

Processing tag recoveries and administration of the reward program continued during 1999. About 720 tags recovered in 1999 have been received so far, compared to a total of 749 in 1998. About 36% of the fish recovered in 1999 had been at liberty for more than 10 years. The two fish at liberty the longest were both tagged in Chatham Strait in 1973 and recovered in Chatham Strait in 1998. Tagging continued on the 1999 longline survey, with 3,868 adult sablefish tagged and released.

An additional 783 sablefish were tagged and released on 3 seamounts in the Gulf of Alaska Seamount Province during the survey vessel transit from the Western to Eastern Gulf. The purpose of releasing tagged sablefish on the seamounts is to determine the extent, if any, of emigration from the seamounts and movement between seamounts. NMFS exploratory fishing on nine Gulf of Alaska seamounts in June and July of 1979 found that sablefish were the dominant finfish on each of the seamounts. Trap catch rates were higher than those from NMFS survey sites off southeastern Alaska, and nearly all sablefish were ripe, spawning, or recently spent. However, only older and larger fish were caught on the seamounts, indicating that the populations there are maintained by the migration of mature fish from the continental slope rather than by local recruitment. Some tagged fish released in the Bering Sea, Aleutian Islands, and the Western and Central Gulf of Alaska have been recovered over the years on Gulf of Alaska seamounts, verifying that slope to seamount migration does occur. It is not known if emigration from the seamounts or exchange between seamounts occurs. Of 99 tagged sablefish released on five Gulf of Alaska seamounts in 1979, five have been recovered on the seamount where they were tagged, and none have been recovered elsewhere.

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

Archival Sablefish Tags

During the 1998 sablefish longline survey, about 196 sablefish were surgically implanted with an electronic archival tag. Two fish were tagged and released at each station from the eastern Aleutian Islands throughout the Gulf of Alaska to Dixon Entrance. The archival tag contains a computer chip that records depth and temperature for a period up to 10 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, twelve tags have been recovered. A $500 reward per tag is being offered to fishermen for the recovery of these tags. Plans are to release an additional number of sablefish with implants of archival tags during the 2000 longline survey.

For more information, contact Michael Sigler at (907) 789-6037 or Thomas Rutecki at (907) 789-6051.

Juvenile Sablefish Studies

Juvenile sablefish studies have been conducted by ABL in Alaska since 1984 and were continued in 1999. Only 14 juvenile sablefish (age 1+) were caught during a cruise of the NOAA ship *John N. Cobb* at St. John Baptist Bay, Sitka Harbor area, and Silver Bay, near Sitka, in April 1999. This was the lowest catch ever for that cruise which has been conducted annually since 1985. However, during the summer of 1999 juvenile sablefish (age 1+) were found in inside waters of southeastern Alaska near Auke Bay for the third consecutive year, and about 1,000 fish were tagged and released in the vicinity of Auke Bay. 1997-99 were the first years since 1985 that large numbers of juvenile sablefish were found around Auke Bay. A young-of-the-year (YOY) sablefish study, which started in 1995, was conducted again in 1999 using the survey vessel *Ocean Prowler* opportunistically during the sablefish longline survey. A small-mesh surface gillnet was fished at night at offshore locations in the Gulf of Alaska to capture YOY sablefish. Mean lengths of YOY sablefish caught in the gillnets during these surveys have ranged from 10 to 19 cm. Analysis of the catch rates from the gillnets indicate that there is promise for using the gillnet survey to predict future year class strength of sablefish. Both the juvenile tagging and YOY sablefish studies are planned to be continued in 2000.

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

Young-of-the-Year Sablefish Age and Growth in the Gulf of Alaska

Ageing of juvenile sablefish from their sagitta otoliths has been completed for fish collected in the Gulf of Alaska from 1995-99. Young-of-the-year (YOY) juveniles (captured before their first winter) were collected with gillnets fished opportunistically during adult sablefish longline surveys conducted each year in the Gulf of Alaska. The sagitta otoliths of 151 fish were chosen (~30 per year) for age determination. The otoliths contain visible increments which are

thought to form daily, much like the yearly rings visible in an adult sablefish otoliths. Daily otolith increment counts revealed that Gulf of Alaska sablefish grew more than one millimeter a day during their first year of life. These growth rates were similar to those reported for sablefish stocks off Oregon and Washington. Analyses also indicated that the first visible otolith increment (possibly the hatch mark or first-feeding date) formed sometime during April and May of each year (mean date of approximately May 1). If first increment formation corresponds to the hatching event, then the estimated hatch dates for Alaska sablefish found in this study would be almost one month later than hatch dates estimated in another study of sablefish found off Oregon and Washington.

Ongoing experiments are being conducted to validate and verify the daily periodicity of otolith increment deposition in YOY sablefish. The validity of daily increment formation is being tested by chemically marking the otoliths of YOY sablefish held in captivity at the Auke Bay Laboratory. In 1998 several fish were immersed twice in baths of sea water containing the chemical strontium. The otoliths of marked fish are then processed and the strontium markers were detected with electron scanning microscopy. The number of increments between chemical markers on each otolith was compared to the number of days between marking events, but the results were inconclusive. Apparently, the fish grew very little between marking events and many of the daily increments were indistinguishable. The experimental procedure was re-evaluated and the experiment is being repeated with sablefish collected from the Gulf of Alaska in 1999. Other validation techniques are also being explored, including the use of chemically marked sagitta otoliths obtained from ongoing NMFS juvenile sablefish studies conducted along the Oregon coast. In addition, the reproducibility of daily increment detection is being verified by conducting within-reader and between-reader comparisons.

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

Benefits of Individual Fishing Quota Management to the Alaska Sablefish Fishery

Individual Fishing Quota (IFQ) management eliminates the race for fish and may improve economic efficiency, conservation, and safety in fisheries with specific catch quotas. Empirical information documenting these effects is limited even though IFQs have been used since the late 1970s. ABL scientists analyzed fishery data from the sablefish longline fishery in Alaska, which came under IFQ management in 1995. Fishery data were compared to fishery-independent data from the annual sablefish longline survey, which acted as a control to separate annual changes in population demographics from changes due to IFQ management. Results showed that IFQ management increased fishery catch rates and decreased harvest of immature fish. Catching efficiency doubled with the change from an open-access to an IFQ fishery. Sablefish are available to the IFQ fishery at an age about 1.5 years older compared to the pre-1995 open-access fishery. The improved catch efficiency of the IFQ fishery reduced variable costs to catch the quota from nine to five percent of landed value, an annual savings averaging US$3.7 million. Decreased harvest of immature fish improved the chance that individual fish will reproduce at least once. Spawning potential of sablefish, expressed as spawning biomass per recruit, increased 36% for the IFQ fishery. Eliminating the open-access fishery's race for fish by allocating the sablefish quota among competing vessels (IFQs) provided two clear benefits that should be considered when evaluating management options for other open-access fisheries.

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

b. Stock Assessment

BERING SEA, ALEUTIAN ISLANDS, AND GULF OF ALASKA

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

From 1998 to 1999, the longline survey abundance index increased 10% in numbers and 5% in weight, and the commercial fishery abundance index increased 11% in weight. These increases follow decreases from 1997 to 1998, so that relative abundance in 1999 is similar to 1997. Exploitable and spawning biomass are projected to increase 3% and 1%, respectively, from 1999 to 2000. Alaska sablefish abundance now appears low and stable. This is a change from previous assessments where abundance appeared low and slowly decreasing**.** Further years' data are needed to confirm that abundance has stabilized.

A simple Bayesian analysis was completed by examining the effect of uncertainty in natural mortality and survey catchability on parameter estimation. A decision analysis was completed using the posterior probability from the Bayesian analysis to determine what catch levels likely will decrease abundance. The decision analysis indicates that a yield of about 17,000 t most likely will keep spawning biomass the same and has only a 20% probability of reducing 2004 spawning biomass to less than 90% of 2000 spawning biomass. The maximum permissible yield from an adjusted $F_{40\%}$ strategy is 17,300 t, which was the 2000 ABC accepted by the North Pacific Fishery Management Council for the combined stock, a 9% increase from the 1999 ABC of 15,900 t.

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

7. Flatfish

b. Stock assessments

BERING SEA

Yellowfin sole

Two abundance estimators (trawl survey and age structure model) all indicate that the yellowfin sole resource increased slowly during the 1970s and early 1980s to a peak during the mid-1980s and that the resource has remained abundant and stable since that time. This trend is consistent with the fact that yellowfin sole is a slow-growing species which has been lightly exploited while experiencing average to strong recruitment during the past 18 years.

The present assessment includes significant changes from last year=s assessment, including use of AD Model Builder as a modeling platform for the first time and incorporation of new catch and survey information. This year's EBS bottom trawl survey resulted in a biomass estimate of 1,310,000 t, a 44% decrease relative to last year's estimate. The sharp decrease appears due to an effect of cold water to decrease availability; water temperatures were the coldest on record in 1999 and previous trawl survey results appear affected by shelf bottom temperatures. The stock assessment model indicates that yellowfin sole biomass has been at a high and stable level since 1985 due to light exploitation and the emergence of strong year-classes in 1981, 1983 and 1991. The population biomass is projected to increase further in the near future.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 577,000 t, 0.11, and 0.13, respectively. Given that the projected 2000 spawning biomass of 789,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2000 were calculated under sub-tier Aa@ of Tier 3. The ABC was set at $F_{ABC} = F_{40\%}$ (=0.11) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2000 ABC of 191,000 t.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.13 gives a 2000 OFL of 226,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Rock sole

The present assessment includes significant changes from last year=s assessment, including use of AD Model Builder as a modeling platform for the first time, use of year-specific weight-at-age schedules, and incorporation of new catch and survey information. This year's EBS bottom trawl survey resulted in a biomass estimate of 1,690,000 t, a 22% decrease relative to last year's estimate. It should also be noted that the biomass estimate from the 1998 survey constituted a 20% decrease relative to 1997. The stock assessment model indicates a high and abundant population decreasing at a rate less than the survey results indicate. The model estimates the population biomass peaked in 1995 and has since declined 20% to 2.1 million t. It is projected at 2.07 million t in 2000.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 285,000 t, 0.15, and 0.19, respectively. Given that the projected 2000 spawning biomass of 676,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2000 were calculated under sub-tier Aa@ of Tier 3. The ABC was set $F_{ABC} = F_{40\%}$ (=0.15) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2000 ABC of 230,000 t.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.19 gives a 2000 OFL of 273,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

The model indicates that biomass has remained high and stable during the mid-1990s, with a slight decline projected for 2000. The 1987 year class was exceptionally strong, and the 1990 year class appears to be above average as well.

Flathead sole

The present assessment is a straightforward update of last year's assessment, incorporating new catch and survey information into the length-based assessment model. This year's EBS bottom trawl survey resulted in a biomass estimate of 395,000 t, a 43% decrease relative to last year=s estimate. This is a departure from the even trend of survey biomass observed in recent years. Model results indicate an abundant and stable stock which has declined 23% from a peak abundance of 795,200 t in 1992. Flathead sole remain lightly harvested in 1999.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 134,000 t, 0.28, and 0.35, respectively. Given that the projected 2000 spawning biomass of 261,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2000 were calculated under sub-tier Aa@ of Tier 3. The recommended $F_{ABC} = F_{40\%}$ (=0.28) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2000 ABC of 73,500 t.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value of 0.35 gives a 2000 OFL of 90,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Other flatfish

Beginning with the 1995 fishing season, flathead sole were removed from the "other flatfish" complex, leaving Alaska plaice as the dominant member of the complex. The complex has remained at a stable, and presumably high, level of abundance throughout the modern history of the EBS survey time series (i.e., since 1982, when the present survey net configuration was adopted). The present assessment includes significant changes from last year=s assessment, including use of AD Model Builder as a modeling platform for the first time (Alaska plaice only) and incorporation of new catch and survey information. This year's EBS bottom trawl survey resulted in biomass estimates of 547,000 t for Alaska plaice and 69,700 t for the remaining species in the "other flatfish" complex, representing an increase of 21% and a decrease of 6% relative to last year's estimates, respectively.

The stock assessment model indicates that the Alaska plaice population biomass peaked in 1984 at 1.2 million t and has since declined an estimated 37% to 760,000 t in 1999 due to reduced levels of observed recruitment.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock complex, and that this stock complex therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 100,000 t (Alaska plaice only), 0.28, and 0.35, respectively. Given that the projected 2000 spawning biomass (Alaska plaice only) of 187,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2000 were calculated under sub-tier Aa@ of Tier 3. The recommended $F_{ABC} = F_{40\%}$ level (=0.28 for all species), which is the maximum allowable under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2000 ABC of 117,000 t for the complex.

The OFL was determined from the Tier 3a formula, where an $F_{35\%}$ value (=0.35 for all species) gives a 2000 OFL of 141,000 t for the complex. Model projections indicate that this stock complex is neither overfished nor approaching an overfished condition.

Greenland turbot

The present assessment is a straightforward update of last year's assessment, incorporating new catch and survey information. This year's EBS bottom trawl survey resulted in a biomass estimate of 19,797 t, a 30% decrease relative to last year's estimate. Conditions do not appear to have changed substantively over the past several years. For example, the abundance of Greenland turbot from the Eastern Bering Sea trawl survey has found only spotty quantities with very few small fish that were common in the late 1970s and early 1980s. The majority of the catch has shifted to longline gear in recent years. The assessment model analysis was similar to last year but with a slightly higher estimated overall abundance. This is attributed this to a slightly improved fit to the longline survey data trend. The target stock size ($B_{40\%}$, female spawning biomass) is estimated at about 81,200 t while the projected year 2000 spawning biomass is about 150,800 t. Given the continued downward abundance trend and no sign of recruitment to the shelf are, it is recommended that the ABC be set to 25% of the maximum F_{ABC} value.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 81,300 t, 0.26, and 0.32, respectively. Projected spawning biomass for 2000 is above $B_{40\%}$, placing Greenland turbot in sub-tier Aa@ of Tier 3. The ratio of 1999 spawning biomass to $B_{40\%}$ has changed dramatically since last year=s assessment: In last year=s assessment, the ratio was 79%, whereas in the present assessment, the ratio is 203%. The main reason for this change is that the recruitments used to estimate $B_{40\%}$ in last year=s assessment included year classes spawned prior to the regime shift of 1977, whereas the recruitments used to estimate $B_{40\%}$ in the present assessment include only year classes spawned during the current environmental regime. The maximum permissible value of F_{ABC} under Tier 3a is 0.26. A fishing mortality rate of 0.26 translates into a 2000 catch of 34,700 t, which would be the maximum permissible ABC under Amendment 56. The Plan Team concurred with the authors= recommendation to set the 2000 ABC at a value substantially less than the maximum permissible, using $F_{ABC} = 0.25 \times max\ F_{ABC}$, which results in a 2000 ABC of 9,300 t. A 2000 ABC well below the maximum permissible value is warranted for the following reasons: 1) estimated age 1+ biomass has trended downward continually since 1972; 2) the 7 most recent age 1 recruitments constitute 7 of the lowest 8 values in the entire time series; and 3) if the maximum permissible ABC of 34,700 t were actually caught, this would constitute the highest catch since 1983, even though spawning biomass in 2000 is projected to be less than half of what it was in 1983.

The OFL fishing mortality rate is computed under Tier 3a, $F_{OFL} = F_{35\%} = 0.32$, and translates into a 2000 OFL of 42,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

Arrowtooth flounder

The present assessment includes significant changes from last year=s assessment, including a return to the method of weighting sex-specific size composition data that had been used prior to last year=s assessment and incorporation of new catch and survey information. This year's EBS bottom trawl survey resulted in a biomass estimate of 244,000 t, a 29% decrease relative to last year's estimate. The length-based assessment model indicates that arrowtooth flounder biomass

peaked in 1995 at 915,000 t and has declined 10% from this peak value in 1999. Female spawning biomass is estimated at a high level, well above $B_{40\%}$.

Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that this stock therefore qualified for management under Tier 3 of the BSAI Groundfish FMP. The updated point estimates of $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ (which replaces $F_{30\%}$ under Amendment 56) from the present assessment are 195,000 t, 0.22 and 0.27, respectively. Given that the projected 2000 spawning biomass of 496,000 t exceeds $B_{40\%}$, the ABC and OFL recommendations for 2000 were calculated under sub-tier Aa@ of Tier 3. The recommended $F_{ABC} = F_{40\%}$ (=0.22) level, which is the maximum permissible level under Tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 2000 ABC of 131,000 t.

The OFL fishing mortality rate is computed under Tier 3a, $F_{OFL} = F_{35\%} = 0.27$, and translates into a 2000 OFL of 160,000 t. Model projections indicate that this stock is neither overfished nor approaching an overfished condition.

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

GULF OF ALASKA

1998 Fishery	ABC	EXPLOITABLE BIOMASS	CATCH
Deep water	7,170	101,430	2,472
Rex sole	9,159	72,330	3,540
Shallow water	43,150	314,960	1,747
Flathead sole	26,110	206,340	2,671
TOTAL	85,580	695,060	10,430

1999 Fishery	ABC	EXPLOITABLE BIOMASS	CATCH
Deep water	6,050	78,300	2,285
Rex sole	9,150	72,330	3,057
Shallow water	43,150	314,960	2,545
Flathead sole	26,110	206,340	891
TOTAL	84,460	671,930	8,778[1]

2000 Fishery	ABC	EXPLOITABLE BIOMASS
Deep water	5,300	74,460
Rex sole	9,440	74,600
Shallow water	37,860	299,100
Flathead sole	26,270	207,520
TOTAL	78,870	655,680

1/Catch through November 6,1999.

The flatfish group is subdivided into deep water flatfishes, rex sole, shallow water

flatfishes, and flathead sole. The 2000 exploitable biomass for each category is based on abundance estimated from the 1999 triennial trawl survey. The ABCs for each group are apportioned among the regulatory areas in proportion to biomass distributions in the 1999 trawl survey. The resulting 2000 ABCs are:

	Western	Central	WYak	EYak/SEO	Total
Deep water	280	2,710	1,240	1,070	5,300
Rex sole	1,230	5,660	1,540	1,010	9,440
Shallow water	19,510	16,400	790	1,160	37,860
Flathead sole	8,490	15,720	1,440	620	26,270
TOTAL	29,510	40,490	5,010	3,860	78,870

The overfishing levels for the flatfish groups are determined by the fishing mortality rates determined from their structure to the exploitable biomass estimates. Those fishing mortality rates and associated catch levels are:

Overfishing:

	F_{ABC}	F_{OFL}	LEVEL	TIER
Deep water	0.075	0.10	6,980	5,6
Rex sole	0.15	0.20	12,300	5
Shallow water	0.15-0.17	0.209-0.25	45,320	4,5
Flathead sole	0.15	0.20	34,210	5

Arrowtooth flounder

YEAR	ABC	EXPLOITABLE BIOMASS	CATCH
1998	208,340	2,062,740	13,063
1999	217,110	2,126,714	16,062[1]
2000	145,360	1,571,670	

1/ Catch through November 6, 1999.

The 2000 exploitable biomass is based on abundance estimates derived from an ADModel Builder stock assessment model. There was a change in the way the model accounted for higher proportions of females in the larger size intervals. In the previous model, the changing sex ratio was fit by having different selectivity for males and females as size increased. In the present model, the sex ratio pattern is fit by giving males a higher mortality rate than females. The Plan Team agreed with the assessment authors that this was a more appropriate way to model the pattern in sex ratio, as this pattern (fewer males at larger sizes) is observed in both the Bering Sea and the Gulf of Alaska, and in both survey and commercial catches. This change is largely responsible for the drop in exploitable biomass estimated in 2000, although there was also a less-dramatic decrease in the trawl survey biomass in the 1999 survey. Biomass estimates are estimated to be greater than $B_{40\%}$ and ABC was determined to be 145,360 t based on Tier 3a calculations ($F_{40\%}$ = 0.134). The ABC was apportioned among regulatory areas in proportion to biomass distributions in the 1999 trawl survey. The resulting ABCs are:

WESTERN	CENTRAL	WYAK	EYAK/SEO	TOTAL
16,160	97,710	23,770	7,720	145,360

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

9. Pacific whiting

b. Stock assessment

The coastal population of Pacific whiting was assessed using an age-structured assessment model. The U.S. and Canadian fisheries were treated as distinct fisheries in which selectivity changed over time. Catch and age data from these fisheries were supplemented with survey data from the Alaska Fisheries Science Center (AFSC) triennial acoustic survey, the AFSC triennial shelf trawl survey, the Department of Fisheries and Oceans acoustic survey, and the Southwest Fisheries Science Center midwater trawl recruit survey. New data in this assessment included updated catch at age, recruitment indices from the SWFSC recruit survey, and results from the triennial acoustic and shelf trawl surveys conducted in summer of 1998.

The whiting stock is at moderate abundance. Stock biomass increased to a historical high of 5.7 million t in 1987 due to exceptionally large 1980 and 1984 year classes, then declined as these year classes passed through the population and were replaced by more moderate year classes. Stock size has been stable over the past four years at 1.7-1.8 million t. The mature female biomass in 1998 is estimated to be 37% of an unfished stock. Although 1998 stock size is near a historical low, it is close to average stock size under current harvest policies. The exploitation rate was below 10% prior to 1993, then increased to 17% during 1994-98. Total U.S. and Canadian catches have exceeded the ABC by an average of 12% since 1993 due to disagreement on the allocation between U.S. and Canadian fisheries.

An age-structured assessment model was developed using AD model builder, a modeling environment for developing and fitting multi-parameter non-linear models. Earlier assessments of whiting used the stock synthesis program. Comparison of models showed that nearly identical results could be obtained under the same statistical assumptions. The treatment of fishery and survey data was similar to previous assessments, except that a new approach to modeling changes in fishery selectivity was introduced.

The whiting assessment is highly dependent on survey estimates of abundance. Since 1993, the assessment has relied primarily on an absolute biomass estimate from the AFSC acoustic survey. The acoustic target strength of Pacific whiting, used to scale acoustic data to biomass, is based on a small number of *in situ* observations. The fit to the entire acoustic survey time series is relatively poor. The AFSC shelf trawl survey biomass shows an increasing trend, conflicting with the decreasing trend in the acoustic survey.

An evaluation of whiting harvest policy led to the recommendation that the 40-10 option be considered for whiting. The 40-10 option results in similar harvest rates as the hybrid F policy used previously for whiting, and may improve economic performance of the fishery by dampening variability in harvests. An appendix to the assessment described a meta-analysis of hake stock-recruit relationships. Results indicated that the genus Merluccius may be less resilient to fishing than other gadoids. A Bayesian decision analysis produced estimates of FMSY in the $F_{40\%}$ to $F_{45\%}$ range depending on the degree of risk-aversion.

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10. Walleye pollock

a. Research

BERING SEA

Acoustic/Trawl Surveys - Bogoslof Island Area

Japan Fisheries Agency (JFA), in cooperation with Alaska Fisheries Science Center (AFSC), conducted an echo integration-trawl (EIT) survey of walleye pollock in the Bogoslof Island region in February-March 1999 aboard the Japanese research vessel *Kaiyo maru*. AFSC's Midwater Assessment and Conservation Engineering (MACE) Program has conducted this survey annually since 1988. In 1999 MACE collaborated with JFA aboard their vessel because NOAA ship *Miller Freeman* was in dry dock for repairs. The region was surveyed twice: Jan. 31-Feb. 9 (leg 1), and Feb. 21-Mar. 4 (leg 2). Leg 2 timing was approximately one week earlier than recent AFSC surveys. The primary cruise objective was to determine the distribution and abundance of pollock that spawn in this region of the southeastern Aleutian Basin. The survey design comprised north-south parallel transects at 10 nmi spacing on leg 1, and 10 or 5 nmi spacing on leg 2 depending on fish distribution.

During leg 1, pollock were encountered along the southern ends of transects, near the Aleutian Islands, especially in Samalga Pass northeast of the Islands of Four Mountains. During leg 2, distribution was similar, but aggregations were larger and more concentrated.. Pollock caught in six midwater hauls during leg 1 had fork lengths ranging from 42-65 cm; those caught in the eight hauls made during leg 2 had fork lengths ranging from 39-67 cm. Hauls made on the eastern-most transects north of Akutan Is. caught smaller pollock (length modes between 42-45 cm) than those in the central and western part of the survey area (length modes 53-57 cm for males, and 55-59 cm for females). Most females were in a pre-spawning stage. Average gonadosomatic index (GSI) for mature female pollock increased from 12.6 during leg 1 to 16.1 during leg 2 and was comparable to female GSI as measured in March 1998. Biomass estimates based on leg 2 data were 0.475 million tons (total), of which 0.393 million tons was in the Central Bering Sea convention (518) area.

Acoustic/Trawl Surveys - Eastern Bering Sea Shelf

The MACE Program completed an EIT survey of walleye pollock on the eastern Bering Sea shelf June 12-July 29, 1999 aboard the NOAA ship *Miller Freeman*. The survey design comprised north-south transects spaced 20 nmi apart (except "horseshoe" area transects 9-12 where spacing was 10 nmi) beginning at longitude 160° 20' W and ending at longitude 178° 55' W. Acoustic data were collected continuously between sunrise and sunset; pollock target strength data and Methot trawl samples for age-0 pollock/zooplankton were collected at night. Pollock acoustic backscatter (from 14 m below the surface to within 0.5 m of the bottom) was absent or very low in the east, but then increased around 165° W northwest of Unimak Island. Pollock backscatter was lower between 166° -167° W and then increased again, remaining relatively continuous from about 168° W to the U.S./Russia border. Highest pollock

concentrations were at approximately 173° W and 177° W. West of the Pribilof Islands, they were rarely found in water shallower than 100 m bottom depths. In 1999, the center of pollock distribution was south and slightly west of that from previous years, and more were found in the Pribilof Island area.

Biological samples of echosign comprised 98 midwater, 14 bottom, 4 Marinovich, and 48 Methot trawls. Pollock captured in midwater/bottom trawls ranged from 9-79 cm in length. Adult pollock (>29 cm fork length) were found throughout the shelf; most smaller fish (<30 cm) were encountered north of the Pribilofs, and again west of 172° W and south of about 60° 30' N . Pollock smaller than 20 cm (age 1 pollock) were only occasionally captured. East of the Pribilofs, pollock modal lengths were 36, 47, and 25 cm; west of the Pribilofs modal lengths were smaller--30, 45, and 22 cm, respectively. Estimated pollock abundance between the surface and 3 m off-bottom was 3.35 million tons and 9.7 million fish for the total survey area. About 11% (0.36 million t), was in Steller sea lion critical habitat (CH) management area, 17% (0.58 million t) was east of 170° W outside CH, and 72% (2.41 million t) was west of 170° W. Using only the area surveyed in 1994, '96, and '97, i.e. excluding transect sections added in 1999, estimated pollock biomass was 3.29 million tons, and 9.6 billion pollock.

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Recruitment Processes - FOCI

Fisheries-Oceanography Coordinated Investigations (FOCI) is a cooperative research program with the Pacific Marine Environmental Laboratory (PMEL), Oceanic and Atmospheric Research (OAR), designed to investigate causes of annual recruitment variations in fish stocks of economic importance in the Gulf of Alaska and Bering Sea ecosystems. The research is directed at understanding the causes of large natural fluctuations of walleye pollock stocks that spawn in Shelikof Strait, Gulf of Alaska, and in the eastern Bering Sea (with support from NOAA's Coastal Ocean Program). This research is based on the paradigm that recruitment of pollock to the mature population is largely set during the egg and larval stages as the result of a host of physical and biological processes determining their survival to the juvenile stage. The objective of this research is to improve the accuracy and extend the time horizon of estimates of recruitment for forecasting future population trends on which to base management decisions on optimal harvest levels. In 1999 FOCI conducted 4 cruises in mid- and late spring aboard the NOAA ship *Miller Freeman* and 2 aboard the Oregon State University ship *Wecoma*. A cruise aboard the Hokkaido University research vessel *Oshoro-maru* surveyed the distribution of age-0 walleye pollock in summer in the southeastern Bering Sea. In September FOCI scientists continued process studies initiated in 1994 to study the habitat characteristics of juvenile walleye pollock around the Pribilof Islands during a two-week cruise aboard the *Miller Freeman*. In summer 1999, as in 1997 and 1998, we observed an unusual bloom of coccolithophorids (small phytoplankton covered with calcium carbonate plates) over the shelf of the Bering Sea.

b. Stock assessments

GULF OF ALASKA

Projected exploitable biomass for age-3+ pollock in 2000 is 588,000 t as derived from the current assessment model. Exploitable biomass for the Southeast Outside and East Yakutat areas was 28,709 t, as derived from CPUE data during the 1999 Gulf trawl survey.

Relative to the 1999 SAFE, new sources of information include: (1) 1997 and 1998 echo integration trawl (EIT) survey age composition; (2) an evaluation of 1989-98 ADF&G coastal trawl survey biomass and length composition data for inclusion in the model; (3) age composition from the 1998 fishery; (4) catch data from the 1999 fisheries; and (5) the 1999 ADF&G summer biomass estimate for Prince William Sound (PWS). The Shelikof EIT survey was not conducted in 1999. In addition, the stock assessment was extended eastward to 140° W to coincide with the area open for trawling in the Gulf of Alaska; this assessment previously extended only to 147° W long. Annual catches and the AFSC bottom trawl survey biomass time series were revised to correspond to the larger area. Biomass estimates in the trawl survey time series were also increased to account for biomass in PWS. Estimates of OFL and ABC alternatives for 2000 were examined through two models: a base-run model that included the ADF&G trawl survey time series for nearshore waters of the Central and Western Gulf; and a model without ADF&G data. Because both models yielded similar trends, ADF&G data were included.

Projected spawning biomass in 2000 for the Western, Central and West Yakutat areas is 214,900 t, which is below the $B_{40\%}$ value of 247,000 t and places Gulf pollock in Tier 3b. The 2000 harvest rate, while less than the maximum permissible of $F_{40\%adjusted} = 0.34$, was recommended to address some of the following concerns: (1) the stock continues to decline; (2) the stock biomass is now at an all time low; and (3) the large variability around the biomass estimate from the 1999 trawl survey. Given the low biomass and continued decline, the Team felt it inappropriate to increase the ABC relative to 1999. Total recommended ABC for Western, Central, and West Yakutat areas is 96,560 t, which represents a fishing mortality rate of F = 0.29. The 2000 ABC was apportioned according to the mean distribution of the exploitable population biomass in the four most recent bottom trawl surveys. ABC apportionment by mean distribution among surveys is a departure from previous pollock assessments and was used because of the high variability observed in the 1999 trawl survey distributions. This resulted in an apportionment of 41.0% (39,590 t) to the Shumagin area, 24.4% (23,560 t) to the Chirikof area, 32.1% (31,000 t) to the Kodiak area, and 2.5% (2,410 t) to the West Yakutat area. OFL for gulf pollock in 2000 is defined as $F_{35\%adjusted} = 0.40$. Pollock in the Southeast Outside and East Yakutat areas fall into a Tier 5 assessment. Under this approach, 2000 ABC is 6,460 t, based on 1999 trawl survey biomass estimate of 28,710 t and a natural mortality estimate of 0.30. OFL is 8,610 t. The assessment authors noted that pollock catch in the pooled Southeast Outside and East Yakutat areas never exceeded 100 t during 1991-98.

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EASTERN BERING SEA

This year's pollock assessment features new data from the 1999 fishery and bottom trawl and echo-integration trawl surveys. The 1999 bottom trawl survey estimated a biomass of 3,570,000 t, an increase of 61% relative to the 1998 estimate. The 1999 echo-integration trawl survey estimated a biomass of 3,290,000 t, an increase of 27% from the 1997 estimate, the last

year an echo-integration trawl survey was conducted in this region. Eight alternative models are presented in the assessment, all of which follow the statistical age-structured approach that was used last year to set ABC for 1999. All but two of these eight models estimate 1999 age 3+ biomass to fall between 7,500,000 t and 8,300,000 t (the other two models give values ranging from 5,800,000 t to 6,600,000 t). Of the eight models presented, the ABC recommendation for 2000 was based on Model 2, which assumes a Ricker stock recruitment relationship and uses the average commercial fishery selectivity pattern from the most recent three years to make projections of future catch and stock size. This is the same model used last year to recommend the 1999 ABC, except that the recruitment distribution used for harvest projections was estimated from year classes spawned after 1976 only. Model 5 is similar, except that the recruitment distribution used for harvest projections was estimated from the entire time series of year classes (1963-1998). Under Model 5, the stock appears to be able to sustain much higher harvest rates than under Model 2. This is because the early portion of the time series, which is used in Model 5 but not in Model 2, shows relatively high recruitments occurring even at low stock sizes. For example, spawning biomass was lower during the period 1966-1968 than at any time during the 1977-1998 portion of the time series, but the 1966-1968 year classes were all above average in strength. The choice of Model 2 is based on the belief that the data in the later portion of the time series are the most reliable and that harvest recommendations should be most heavily influenced by current information and the stock=s current productive capacity (i.e., since the 1977 regime shift). Model 2 estimates an increase of 26% in age 3+ biomass between 1998 and 1999, followed by a projected increase of 9% between 1999 and 2000. The large increase between 1998 and 1999 is fueled by the entry of the 1996 year class into the age 3+ stock, a year class which is currently estimated to be well above average in strength. This increase may have been accentuated by a change in the distribution of pollock in the Bering Sea due to very cold water temperatures in 1999. Projections of age 3+ biomass beyond 2000 are not available, but spawning biomass is projected to remain constant from 2000 to 2001, then decrease in 2002.

Last year, the SSC 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 qualified 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, a conclusion with which the Plan Team concurred. The updated estimates of B_{MSY} and the harmonic and arithmetic means for F_{MSY} from the present assessment are 1,790,000 t, 0.50, and 0.80, respectively. Projected spawning biomass for 2000 is 2,160,000 t, placing EBS walleye pollock in sub-tier Aa@ of Tier 1. The maximum permissible value of F_{MSY} under Tier 1a is 0.50, the harmonic mean of the probability density function for F_{MSY}. A fishing mortality rate of 0.50 translates into a 2000 catch of 1,200,000 t, which would be the maximum permissible ABC under Tier 1a. However, the senior assessment author recommends setting ABC at a lower value, specifically, the maximum permissible level that would be allowed under Tier 3. The Tier 3 reference points $B_{40\%}$ and $F_{40\%}$ are estimated at values of 2,340,000 t and 0.48, respectively. Because projected spawning biomass for 2000 is below $B_{40\%}$, the maximum permissible value of F_{ABC} that would be allowed under Tier 3 is the adjusted $F_{40\%}$ rate of 0.46. The 2000 catch associated with a fishing mortality rate of 0.46 is 1,100,000 t, an 8% reduction from the maximum permissible level under Tier 1. The Plan Team concurred with the senior assessment author that a 2000 ABC of 1,100,000 t was appropriate. The Plan Team wished to emphasize that use of the Tier 3b formula to recommend a 2000 ABC is not intended to change EBS walleye pollock=s classification as a Tier 1 stock, but rather to maintain consistency with the existing harvest strategy pending further evaluation of

three issues:

1) While the Plan Team feels that the Tier 1 reference points are reliably estimated given current model structure, it concurs with the senior assessment author that some issues surrounding model specification remain to be addressed. In other words, alternative model structures should be explored to determine if the current model structure adequately captures the degree of uncertainty surrounding reference points such as F_{MSY}. Some alternative model structures might focus on use of the stock-recruitment relationship and the effect of regime shifts thereupon. The Plan Team notes that the MSY estimate from Model 5 is 33% greater than the estimate from Model 2, and that the F_{MSY} estimate from Model 5 is 211% greater than the estimate from Model 2.

2) The data used in Model 2 included an estimate of the 1999 age composition from the EIT survey that was constructed by applying an age-length key from the bottom trawl survey to the EIT survey=s length composition. The data used in Model 0 did not include this estimate. The maximum permissible ABC for 2000 under Model 0 was 19% lower than under Model 2. Tests with data from prior years showed that application of the bottom trawl survey age- length key to the EIT survey=s length composition sometimes gives a good estimate of the EIT survey=s age composition, but not always.

3) The impacts of Russian pollock harvests in the western Bering Sea on future recruitment of the eastern Bering Sea stock are currently unknown but potentially significant.

The OFL fishing mortality rate under Tier 1a is 0.80, the arithmetic mean value of F_{MSY}. A fishing mortality rate of 0.80 translates into a 2000 OFL of 1,680,000 t. Model projections indicate that the EBS walleye pollock stock is not overfished. The projections necessary for a formal determination of whether this stock is *approaching* an overfished condition are not yet available. However, the senior assessment author anticipates that these projections will be completed soon, and all preliminary indications are that this stock is not approaching an overfished condition.

ALEUTIANS

The 1997 bottom trawl survey of the Aleutian Islands region resulted in a biomass estimate of 106,000 t, an increase of 23% relative to the 1994 estimate. The 1997 stock assessment concluded that the model which had been used to recommend ABC for 1997 was no longer reliable due to the confounding effect of immigration from other areas, and the SSC determined that Aleutian pollock qualified for management under Tier 5. The recommended 1998 and 1999 ABC was 23,800 t, computed as the product of the 1997 survey biomass estimate and 75% of the natural mortality rate (0.3). The recommended 1998 and 1999 OFL was 31,700 t, computed as the product of the 1997 survey biomass estimate and the natural mortality rate. The Plan team recommended retaining the 1997 survey biomass estimate as the best available estimate of biomass in 1999 (by assuming that growth and recruitment balance mortality), and keeping 2000 ABC and OFL at their respective 1999 levels. 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 1999 hydroacoustic survey of the Bogoslof region resulted in a biomass estimate of 475,000 t. Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, with values of 2,000,000 t, 0.27, and 0.37 respectively, and that Bogoslof pollock therefore qualified for management under Tier 3 (the $B_{40\%}$ estimate of 2,000,000 t presumably includes both males and females).

This year=s assessment includes an age-structured model for Bogoslof pollock that calls the $B_{40\%}$ estimate of 2,000,000 t into question. The new age-structured model gives a females-only $B_{40\%}$ estimate of 96,800 t, which is a full order of magnitude lower than the previous estimate, even after correcting for the combined-sexes nature of the old estimate. The senior assessment author has not been able to reproduce the calculations that led to the original acceptance of the old estimate several years ago. The Plan Team thus recommends that Bogoslof pollock be moved from Tier 3 down to Tier 5, based on the following rationale: 1) Until questions surrounding computation of $B_{40\%}$ for this stock are resolved, it is not clear that a reliable estimate of this quantity exists, which implies that Bogoslof pollock should move down to at least Tier 4. 2) Given that there has been no fishery on this stock for so long and that selectivity patterns estimated for the shelf stock are probably not applicable to the deep- water Bogoslof stock, it is not clear that a reliable estimate of fishery selectivity--and thus $F_{40\%}$-exists, which implies that Bogoslof pollock should move down to at least Tier 5. 3) It appears that a reliable estimate of natural mortality (0.20) does exist, which places Bogoslof pollock in Tier 5. Placement of Bogoslof pollock in Tier 5 would classify it similarly with Aleutian pollock, a stock which generally has about the same quality of assessment information.

The recommended 2000 ABC and OFL are based on the hydroacoustic survey estimate for the entire spawning aggregation (475,000 t), rather than the biomass observed in Area 518 alone (393,000 t). Because the hydroacoustic survey is attempting to measure the biomass of a discrete spawning aggregation, it is appropriate to use the entire biomass estimate rather than the proportion of the estimate that happened to reside in Area 518 at the precise time of the survey. In previous SAFE reports, ABC calculations were made by projecting the hydroacoustic biomass estimate forward to account for natural mortality, but not growth or recruitment. In contrast, growth and recruitment have been assumed to balance natural mortality for all other BSAI stocks lacking an age- or length-structured assessment model.

Anticipating that the SSC will concur with the Plan Team=s recommendation to move the Bogoslof pollock stock to Tier 5, the maximum permissible 2000 ABC is 71,300 t (= 475,000 t $\times$ $M \times 0.75$), which is the Plan Team=s recommended ABC. Other alternatives include the following: 1) If Bogoslof pollock remains classified in Tier 3 and the age-structured model contained in the stock assessment is used, the maximum permissible value of F_{ABC} is 0.23, giving a maximum permissible 2000 ABC of 110,000 t. 2) If Bogoslof pollock remains classified in Tier 3 and last year=s estimates of reference points are retained, the maximum permissible value of F_{ABC} is 0.053, giving an exploitation rate of 0.047 and a maximum permissible 2000 ABC of 22,300 t.

Similarly, the 2000 OFL is 95,000 t (= 475,000 t $\times$ M). As a Tier 5 stock, it is not possible to determine whether Bogoslof pollock is overfished or whether it is approaching an overfished condition. Other alternatives include the following: 1) If Bogoslof pollock remains

classified in Tier 3 and the age-structured model contained in the stock assessment is used, F_{OFL} is 0.29, the 2000 OFL is 132,000 t, and Bogoslof pollock is neither overfished nor approaching an overfished condition. 2) If Bogoslof pollock remains classified in Tier 3 and last year=s estimates of reference points are retained, F_{OFL} is 0.064, the 2000 OFL is 30,400 t, and the stock is overfished (because the projected 2000 biomass of 475,000 t is less than 2 of $B_{35\%}$, where $B_{35\%}$ is computed as 2,000,000 t × 7/8 = 1,750,000 t).

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

13. Other Species - Atka mackerel

a. Research

Identification and Characterization of Atka Mackerel Reproductive Habitat

In August 1999, RACE and REFM fishery scientists collaborated for a second consecutive year to find areas in the Aleutian Islands where Atka mackerel spawn. No nesting sites were found in 1998 after searching 10 days in the eastern end of the Aleutian chain near Unalaska. This year's efforts focused in the central Aleutians around Seguam Island and near the northeast corner of Amlia Island.

The basic biology of Atka mackerel is poorly studied despite its commercial value and importance as a key forage species for the endangered Steller sea lion and other marine piscivores. A peculiar aspect of Atka mackerel life history is that the adults switch from a predominantly pelagic to mostly demersal existence during the spawning season. In the summer and early fall, adults migrate to shallower water where females deposit their eggs onto rocky substrate. Males fertilize the demersal egg clusters and remain behind to guard a territory containing batches of embryos ("nests"). Such nesting sites have been documented in Russian waters but have never been verified in U.S. waters until now.

The commercial fishing vessel *Vesteraalen* was used as the primary support vessel. A 6-m rigid-hulled inflatable was deployed from the support vessel and used for exploring nearshore areas. Underwater video and SCUBA diving were the primary research tools to locate and study Atka mackerel nesting areas. The towed video camera we used did not have adequate resolution to detect the embryo clusters as it was dragged through the water. Direct observations by divers were necessary to verify the presence of nests. During 5 days of actual fieldwork, scientists made a total of 18 man-dives, filmed more than 8 hours of underwater video footage, collected numerous biological specimens with hook-and-line (jigging) and spearfishing, and measured depth and temperature at nesting sites. The principal nesting site chosen for most of this work was on the northeast side of Seguam Island south of Finch Cove. The depth of the dive site was between 15 and 30 m and the bottom consisted of rock outcrops interspersed with moderate-sized boulders less than one-half meter in diameter. Fist-sized clumps of embryos were deposited in the interstices of boulders and their color blended with the encrusting algae and other marine life. Nest sizes were difficult to discern because males were guarding non-discrete batches of embryos spread over areas more than 1 m in diameter. Behaviors of aggregated adults and guardian males at nesting sites were observed *in situ* using an autonomous underwater video recorder. Strip transects were also used to estimate the density of nests. Stomachs of red Irish lord , yellow Irish

lord, Pacific cod, and male Atka mackerel that we captured in the nesting area all contained Atka mackerel embryo masses, indicating predation and cannibalism of Atka mackerel nests were common.

RACE and REFM scientists plan to continue exploring the temporal and spatial distribution of Atka mackerel nesting areas in the central and western Aleutian Islands as well as to learn more about this peculiar fish's nesting habitat and behavior. Such information may ultimately be useful for developing an index of potential year-class size for this important commercial and forage species.

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

4. Other Related Studies

Research on "Habitat Areas of Particular Concern"

Recent amendments to Fishery Management Plans for the Gulf of Alaska (GOA) state that certain areas of the seafloor deemed especially sensitive to natural or human caused impacts may be classified as Habitat Areas of Particular Concern (HAPC). According to the North Pacific Fishery Management Council, a particular habitat may receive this designation if it is of ecological importance to the species in question, is sensitive to degradation due to a lack of ecological resilience, has a high probability of being exposed to fishing or other impacts, or is rare or unique. Cursory *in situ* observations of a high-relief, hard-bottom area located approximately 20 nautical miles offshore of Cape Ommaney in Southeastern Alaska indicate that this complex habitat feature supports an especially rich assemblage of epifaunal invertebrate species, including red tree coral (*Primnoa willeyi*) and a variety of large erect sponges. It appears to be surrounded by a region of low-relief gravel substrate that is representative of most of the continental shelf in the GOA, and has been subject to commercial fishing by both trawlers and longliners.

Some rockfish (*Sebastes* spp.) are highly associated with red tree coral, and red tree coral appears to be particularly sensitive to trawl damage. Gorgonian corals, particularly sub-arctic deep-water species, are thought to be extremely slow growing. ABL biologists will conduct an intensive survey from a manned submersible in the area off Cape Ommaney in May 2000. The survey will chart areal extent and bathymetry of this section of seafloor, identify and enumerate associated vertebrate and invertebrate taxa, and classify habitat according to the scheme proposed by Greene et al. (1999). This information should prove useful to fishery managers regarding suitability of the area for designation as a HAPC.

For more information, contact Linc Freese at (907) 789-6045.

Effects of Fishing on Sea Floor Habitat

A Description of Seafloor Habitat in a Trawled Region and a Protected Region of the Central Gulf of Alaska

A study to describe seafloor habitat in a trawled region and a protected region of the Central Gulf of Alaska was initiated by ABL in June 1998. An 11-day research cruise was completed on 24 August 1999. This was the final cruise of the two-year study using a manned submersible to make observations of the seafloor in areas open to bottom trawling and adjacent areas which have been closed to bottom trawling since 1986. The no-trawling areas were closed by the North Pacific Fishery Management Council to assist in rebuilding severely depressed crab stocks. A bottom-trawl fishery occurs adjacent to the closed areas for walleye pollock, flathead sole, butter sole, arrowtooth flounder, Pacific cod, and several species of rockfish. The purpose of the study was to assess changes to the seafloor caused by chronic, long-term trawling. Study objectives were to compare areas closed to trawling to areas open to trawling to determine if differences exist for infauna composition, fish and invertebrate populations, and substrate characteristics including grain-size composition, biogenic structures, and total organic carbon content.

During the August 1999 cruise one of two sites investigated in 1998 was revisited and a third site 25 km south of the Trinity Islands was investigated. The three study sites selected span 200 km along the east side of Kodiak Island and extensive bottom trawling had occurred at all sites in the five years preceding this study. Forty five transects were completed using the submersible, and visual counts and observations were made over 135 km of the seafloor. Each transect sampled was 3,000 m long and bisected the boundary between open and protected areas. Substrate samples were collected with a Shipek bottom sampler along each transect (N =3 to 6 per transect). The sea floor at two sites was a relatively flat and unstructured bottom comprised of mostly fine sand and silt interrupted only by dense beds of several species of sea whips. Evidence of bottom trawling (e.g., trawl door furrows, broken sea whips) was observed at about one-third of the transects. The sea floor at the Trinity Island site was characterized by a gradual change from fine-grained sediment at the open area to coarser sediments in the protected area. At this site, trawl tracks were visible along all transects in the area open to bottom trawling. Fish and invertebrates observed from the submersible included adult and juvenile flatfish, weathervane scallops, juvenile Tanner crabs, hermit crabs, sea anemones, sea stars, and sea whips. Video footage is currently being analyzed for counts of fish and invertebrates in the trawled and non-trawled zones. Infauna composition, sediment grain size, and organic carbon content analyses are near completion.

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

Trawling Effects on a Hard-bottom Habitat in the Eastern Gulf of Alaska

Hard bottom (boulder, cobble, pebble) seafloor on the continental shelf in the Gulf of Alaska provides complex habitat due to the three dimensional nature of the substrate and attached epifauna. Areas providing complex habitat are generally biologically productive, and may be especially sensitive to disturbance by commercial fishing activity. Such an area in the eastern GOA was experimentally trawled in 1996 by personnel from the Auke Bay Laboratory. The experiment showed that after a single trawl pass certain sessile invertebrates, particularly large erect sponges that provide most of the invertebrate structure and biomass in the area, were the organisms most likely to be immediately reduced in number or damaged by the trawl. A follow up

study of the trawl tracks was conducted in 1997, one year post-trawl, to determine if delayed mortality of damaged organisms resulted in further diminution of population densities, or conversely, if recovery of those organisms had taken place. Recent analysis of the 1997 data showed that population density of sponges remained lower than in areas that had not been trawled, and that repair of damage to individual sponges had not taken place during the elapsed year.

For more information, contact Linc Freese at (907) 789-6045.

Workshop on Fishing Gear Impacts

A workshop on fishing gear impacts and seafloor mapping was hosted in Juneau by the Auke Bay Laboratory and the NMFS Regional Office on Jan 25-27, 2000. The focus of the workshop was to improve communications within NMFS on this subject and coordinate AFSC studies with the U.S. Geological Survey (USGS), the National Undersea Research Program (NURP), and the National Ocean Service (NOS), participants in the NOAA/USGS joint initiative on effects of fishing and habitat mapping. A major outcome of this workshop was the development of plans for future research. Short-term plans focus on identifying the effects of the various gear types (i.e., trawls, longlines, pots, and dredges) on fish habitat for a range of habitat types, mapping habitat, examining the associations between habitat features and fish utilization, and defining the geological processes that will allow comparison of natural versus gear effects processes. Long-term plans call for studies that establish the connections between habitat, fish production, and population dynamics and the mitigation of effects through gear design.

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

Effects of Trawling on Hard Bottom Habitat in the Aleutian Region
1999 Field Season Activities at Seguam Pass - RACE

The area around Seguam Pass has been fished for decades and at one point the North Pacific Fisheries Management Council cited it as possibly having experienced significant trawl damage, especially to gorgonian corals. In response, RACE Division scientists initiated a study to visually verify the status of that demersal environment. A simple, robust observation platform was required because the passes that cross the Aleutian Archipelago are notorious for swift currents and irregular terrain, making the use of submersibles and ROV's impractical. RACE scientists adapted the design for a "towed automatically compensating observation system" or TACOS, developed by engineers and scientists at the CSIRO laboratory in Hobart, Tasmania. The apparatus uses an underwater color video camera and AC lighting. Electricity and video signals are transmitted through an electrical tow cable as the camera frame tracks 1-2 meters above bottom. In flat towing attitude, distance above bottom is controlled by counterbalancing flotation with the weight of a drag chain. Live-feed video on the tow vessel's bridge allows the operator to control the amount of deployed cable, responding to changes in the terrain.

In August 1999, RACE Division conducted a 14-day cruise aboard the chartered fishing vessel *Vesteraalen* to gather underwater video images of the demersal habitat in the Seguam Pass

area. The objectives of this study were: 1) examine whether the corals in heavily trawled areas are more damaged and less abundant than in nearby, less trawled areas and 2) attempt to verify the extent to which fish and invertebrates use coral for shelter. Twenty-five successful camera tows were completed. Images were recorded digitally on videotape. The videotapes are currently being reviewed and evaluated at the AFSC. In general, the study area is extremely varied, ranging from dense "gardens" of benthic invertebrates to large underwater sand dunes. On several occasions we recorded what appeared to be Atka mackerel spawning activity on large, offshore rockpiles and pinnacles.

For more information, contact Harold Zenger, (206) 526-4158.

Surficial Sediment Data Base and Mapping

The AFSC continues to collaborate with USGS, Geological Survey of Canada, and the Ocean Sciences Institute (OSI) at the University of Sydney, Australia, to make a surficial sediment map of the U.S. west coast continental shelf and relate the distribution of fish and invertebrate species caught in RACE triennial bottom trawl surveys to bottom type. They are using a fuzzy logic database developed by a senior research fellow at OSI which can use both qualitative and quantitative data. The system enables the user to create numerical values for qualitative data points and use them for analysis, if needed, or retrieve specific data types based on queries. So far they have collected and entered about 10,000 data points with good coverage for large portions of the triennial survey area. They will continue to add more data sets as they become available and attempt to fill holes in the sediment map. AFSC research is focused on the possible importance of rocky untrawlable areas in biomass estimation of some species, the significance of unusually small catches in the early years of the survey, and the need for a proper species assemblage analysis for relating fish to habitat type. If the group can demonstrate relationships between fish and some measure of sediment type, then they may be able to test the validity of stratum boundaries currently used in the triennial survey, which are based on latitude and depth, and suggest new boundaries based on other biologically significant factors.

Research results of the group have been presented as a paper entitled "Use of surficial sediment information and species assemblage analysis for improving trawl survey stratification and abundance estimation" at the NMFS National Stock Assessment Workshop in Seattle, March 28 and as posters at the 1999 Annual Meeting of the American Geophysical Union and at the recent Western Groundfish Conference in Sitka.

For more information, contact Mark Zimmermann, (206)526-4119.

Survey Gear Performance Research

The Effect of Trawl Speed on Footrope Contact of a Survey Trawl

Most RACE Division groundfish assessment bottom trawl surveys have, for years, maintained a towing speed standard of 3.0 knots speed over ground (SOG). However, the catchability of our survey trawls may change with towing speed because of its affect on trawl

dimensions and fish swimming speed. The between-tow variability in CPUE caused by changes in trawl geometry might be reduced if we were to instead standardize towing speed to speed through water (STW). In an experiment conducted off the coast of Washington in September 1999, we examined whether changing towing speeds (STW) had an effect on footrope contact with the bottom, a situation which could potentially affect fish escapement beneath the trawl.

The *F/V Sea Storm* was chartered for eight days to tow our standard Poly Nor'Eastern bottom trawl fitted with roller gear at half-knot increment speeds ranging from 2.0 to 5.0 knots SOG as determined by differential GPS. In addition to a locally moored current meter set 3 meters from the bottom, two current meters were mounted to the trawl to monitor STW. Bottom contact was measured by means of a pivoting tilt meter mounted to a sled that attached to the center of the footrope, permitting continuous contact with the sea bed even when the centermost bobbins lifted. Tilt measurements were later calibrated to distance off bottom. A video camera was used to verify whether the sled and tilt meter were forced off bottom due to excessive water pressure and to describe the varying levels of footrope contact at the different towing speeds. Observations were classified as: 5) best contact, center bobbins rolling; 4) center bobbins not rolling but close enough to bottom to create a mud cloud; 3) center bobbins off bottom but tilt meter still in contact; 2) center bobbins and tilt meter not in contact with bottom, but the bottom still in view; 1) bottom no longer in view.

Bottom contact and STW data were collected for 19 tows, each spanning a 2.5 - 5.0 knot range of towing speeds. Door collapse occurred at several of the 2.0 knot speed increments as evidenced by a rapid decline in wing spread suggesting that the lowest STWs used in the experiment were at the operational limit of our trawl. The relationship between distance off bottom (cm) and trawl speed through water is described by the equation: distance = 5.60 - 5.90 STW +1.55 STW^2 . At speeds under 2.7 knots STW the footrope made hard contact with the sea floor. At 3.0 knots STW, our standard survey target speed, the center bobbins came off 2 cm on average. At 4.0, 4.5, and 5.0 knots STW the centermost bobbins lifted by 7, 10, and 15 cm, respectively. However, at speeds greater than 4.5 knots the predicted distances off bottom are likely underestimated because the tilt meter was often observed losing contact, and in many cases the bottom could no longer be seen.

The evidence that footrope contact and trawl fishing dimensions vary over this range of towing speeds is clear, making for a strong case to monitor STW during our groundfish assessment surveys. What is not certain, however, is whether fish escapement beneath the footrope is any different when the footrope is in contact with the sea floor, 2 cm, or even 7 cm off bottom. A study aimed at quantifying the escapement underneath the trawl at varying trawl speeds using an underbag is scheduled for this summer.

For more information, contact Ken Weinberg, (206) 526-6109.

Retrospective Evaluation of Bottom Trawl Survey Information

A review of the west coast triennial bottom trawl survey time series (1977-1998) revealed a large number of hauls with either no catch or unusually small catches, particularly during the first three survey years (1977-1983). There is some concern that the footrope of our trawl may not have been in contact with the bottom during all or part of these tows, thus yielding lower CPUE values. Standard biomass calculations which included these tows, originally judged to be

successful samples, may have impacted stock assessments for a number of species. Since 1986, technological advances have provided us with a clearer understanding of how our gear operates. This knowledge has led to a subtle evolution of trawling procedures and influenced our process for evaluating the performance of tows and whether they should be used to estimate biomass. These changes have implications for the way that survey information is interpreted for stock assessments.

For more information, contact Mark Zimmermann, (206)526-4119.

GIS Resources

The GIS software used throughout the AFSC is ArcView 3 for PC. Basemaps and baseline data have been acquired from commercial or public access sources or developed in-house, primarily by Angie Greig (206-526-4236) of the REFM Division. Jan Benson has been hired and will act as an AFSC-wide resource available to help and assist the Divisions and Labs in the implementation and use of GIS technology. Jan has a MS in Cartography and a BS in Zoology, both from the University of Wisconsin. She has extensive experience in both cartography and GIS technology and spent several years at the Los Alamos Laboratory. Recently she has been under contract from the University of Washington to RACE/FOCI working on the Atlas of the Spatial Distribution of Various Species of Ichthyoplankton.

APPENDIX I - Recent publications and reports pertaining to groundfish and marine habitats by authors at the Alaska Fisheries Science Center. These reports are primarily products of the RACE Division, REFM Division and the Auke Bay Laboratory.

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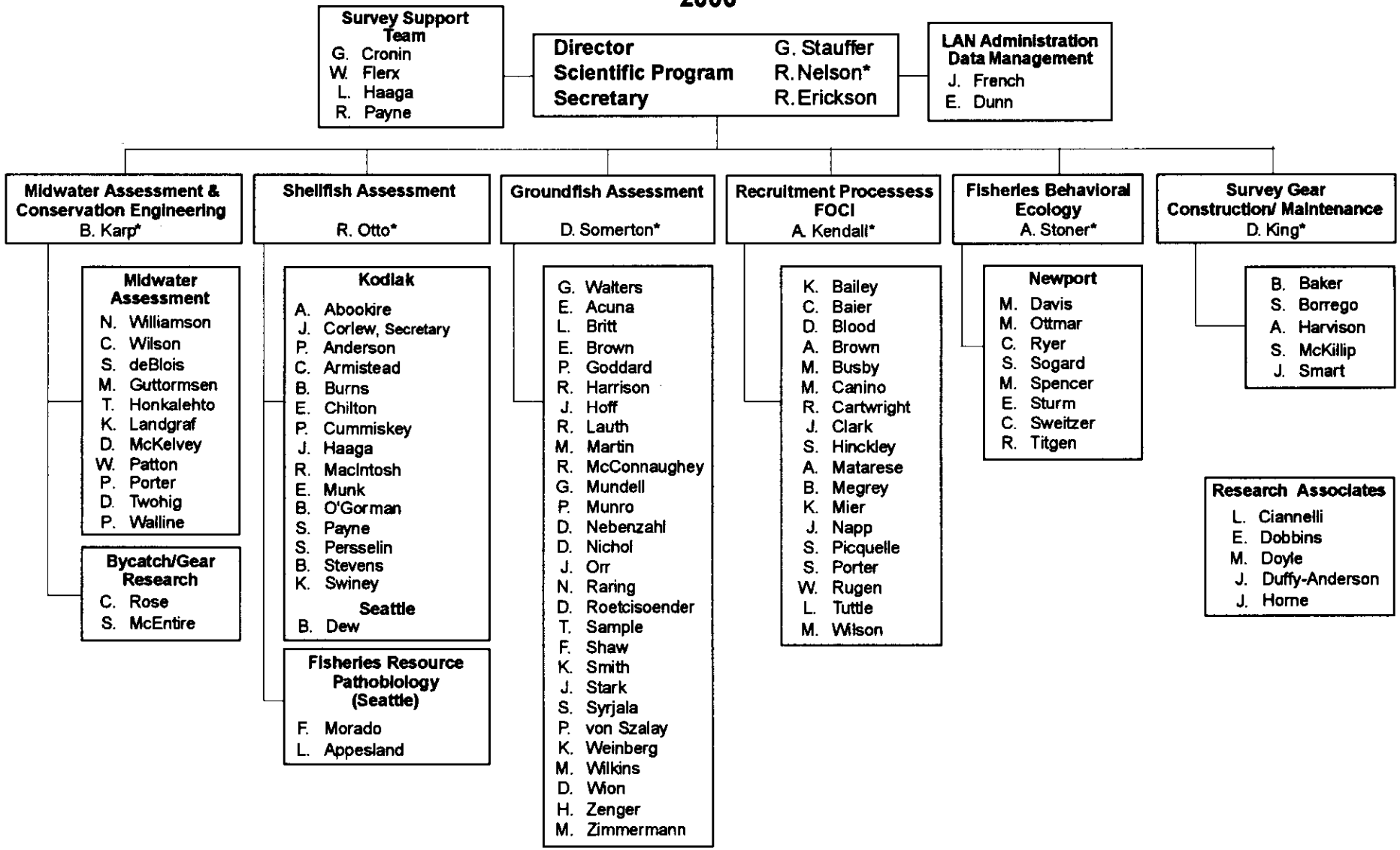
APPENDIX II.--RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION ORGANIZATION CHART 2000



* Program Manager

May 2000

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Loh Lee Low -- Deputy Director

North Pacific Groundfish Observer Program

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Berger, Jerry
Brown, Michael
Campbell, Glenn
Corey, Sheryl
Dakan, John
Davis, Sharon
Decker, Daniel
DeMorett, Kim
Ferdinand, Jennifer
Fitzgerald, Shannon
Hewitt, Robert
Kenney, Heather
Kruse, Kenneth
Limpinsel, Douglas
Loefflad, Martin
Loomis, Todd
Maier, Robert
Martin, Troy
McCauley, Kathleen
Moser, John
Narita, Ren
Neidetcher, Sandra
Nordeen, Carrie
Parker, Todd
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Ridley, Patricia
Risse, Peter
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Goiney, Bernard
Lang, Geoffrey
Yang, Mei-Sun

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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, Sablefish, Stock Assessment
Linc Freese	Effects of Fishing
Jeff Fujioka	Sablefish, Rockfish, Stock Assessment
Jon Heifetz	Rockfish, Sablefish, Stock Assessment, Effects of Fishing
John Karinen	Gulf of Alaska Groundfish
Ken Krieger	Effects of Fishing, Gulf of Alaska Groundfish
Chris Lunsford	Rockfish, Sablefish, Stock Assessment
Nancy Maloney	Sablefish Tag Database, Gulf of Alaska Groundfish
Tom Rutecki	Sablefish
Mike Sigler	Sablefish, Stock Assessment
Robert Stone	Effects of Fishing

Other ABL Staff Working on Groundfish

Scott Johnson	Essential Fish Habitat
Bruce Wing	Groundfish Early Life History