Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 98-05

A Review of Groundfish Research, Assessments, and Management Conducted at the Alaska Fisheries Science Center During 1997

A Report from the Alaska Fisheries Science Center,
National Marine Fisheries Service, to the 1998 Annual Meeting
of the Technical Subcommittee, Canada-U.S. Groundfish Committee

August 1998

ERRATA NOTICE

This document is being made available in .PDF format for the convenience of users; however, the accuracy and correctness of the document can only be certified as was presented in the original hard copy format.

Inaccuracies in the OCR scanning process may influence text searches of the .PDF file. Light or faded ink in the original document may also affect the quality of the scanned document.


NATIONAL MARINE FISHERIES SERVICE
1871
125th ANNIVERSARY
1996
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

A REVIEW OF GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT CONDUCTED AT THE ALASKA FISHERIES SCIENCE CENTER DURING 1997

A Report from the Alaska Fisheries Science Center,
National Marine Fisheries Service, to the 1998 Annual Meeting
of the Technical Subcommittee, Canada-U.S. Groundfish Committee

Compiled by

Mark Wilkins, Tom Wilderbuer, and David Clausen

August 1998

Preface

Groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted by the Center's Resource Assessment and Conservation Engineering (RACE) Division, the Resource Ecology and Fisheries Management (REFM) Division, and the Auke Bay Laboratory (ABL). The groundfish research and assessments of these organizations are divided along regional or disciplinary lines into a number of tasks and subtasks. A review of pertinent work by these tasks from 1997 to 1998 is presented below. A list of recent publications and reports produced by RACE, REFM, and ABL scientists are presented in the Appendix.

Resource Assessment and Conservation Engineering (RACE) Division

In 1997 the primary activity of the RACE Division continued to be fishery-independent stock assessments of important groundfish species of the northeast Pacific Ocean and Bering Sea. The Division's major emphasis in 1997 was in the Aleutian Islands and Eastern Bering Sea regions, in keeping with the triennial rotation of comprehensive surveys among three major geographic areas. The focus will be in the West Coast region in 1998. Three major bottom trawl surveys of groundfish resources were conducted in 1997 by RACE researchers in the Bering Sea, Aleutian Islands, and West Coast. The Midwater Assessment and Conservation Engineering (MACE) Task conducted a comprehensive acoustic survey of pollock abundance in the eastern Bering Sea in July-September 1997 and two acoustic surveys of pollock abundance in the Gulf of Alaska and Bering Sea in March 1998. The Conservation Engineering group has also been refining methods used to stabilize research survey trawls, monitor the fishing configurations of sampling trawls, and explore possible methods of reducing bycatch. Underwater video and scanning sonar are being used to study the behavior of fish encountering trawl gear with the purpose of detecting behavior differences among species and size classes which might be exploited to reduce bycatch. The Recruitment Processes task conducted several Fisheries-Oceanography Coordinated Investigations (FOCI) cruises during the spring and summer of 1997, investigating the interaction between the environment and the spawning products of Gulf of Alaska and eastern Bering Sea pollock.

For more information on overall RACE Division programs, contact Division Director Dr. Gary Stauffer (206)526-4170.

Resource Ecology and Fisheries Management (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 U.S. 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 the 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.

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

Auke Bay Laboratory (ABL)

The AFSC's Auke Bay Laboratory (ABL) is located in Juneau, Alaska. ABL's groundfish task (part of the laboratory's Marine Fishery Resources Program) is primarily involved with research and assessment of sablefish and rockfish in Alaska. Presently, the groundfish task is staffed by 12 permanent biologists. Two personnel changes in 1997 were the transfer of Robert Stone from ABL's Habitat Program into the groundfish task, and the hiring of Chris Lunsford, who formerly was a graduate student at the University of Alaska Fairbanks, Juneau Center, School of Fisheries and Ocean Sciences.

In 1997 field research, ABL's groundfish task, in cooperation with the AFSC's RACE Division, conducted the annual NMFS sablefish longline survey in Alaska. Other field work by ABL included 1) two manned submersible studies: one to determine the catchability coefficient of shortraker and rougheye rockfish on the gear used in the longline survey and the other to determine the effects of bottom trawling on the seafloor, 2) continued juvenile sablefish studies, and 3) a study to identify rockfish larvae to species.

Ongoing analytic activities involved management of ABL's sablefish tag database and preparation of three annual status of stocks documents for Gulf of Alaska groundfish: sablefish, slope rockfish, and pelagic shelf rockfish. Also, laboratory studies on rockfish genetics were continued, and plans were made to conduct an adaptive sampling experiment on slope rockfish in 1998.

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

Multispecies Studies (Research)

1997 RACE Bering Sea Crab/Groundfish Bottom Trawl Survey

The annual crab-groundfish demersal trawl survey of the eastern Bering Sea shelf was conducted from 7 June to 26 July 1997. A total of 376 stations were sampled, covering over 500,000 km^2 from inner Bristol Bay to the shelf edge and from Unimak Pass to 62°N lat. near St. Matthew Island. The chartered vessels F/V *Aldebaran* and F/V *Arcturus* were used for the survey for the fifth consecutive time. Preliminary biomass estimates for major species indicated little differences from 1996 with the exception of northern rock sole (up significantly to 2,700,000 t) and Pacific cod (down significantly to 605,000 t).

Exceptionally good weather during the first 6-7 weeks of the survey (low wind and high insolation) created higher surface water temperatures. Within inner Bristol Bay the surface anomaly was +1.7°, the highest seen since 1983. Over deeper waters the anomaly was also positive, but to a much lesser degree. Bottom temperatures throughout the survey area were near the long-term mean.

The good weather also allowed the completion of the survey in time for additional experiments to be performed. Both vessels used specially designed nets and video equipment to

examine the escapement of fish and crab species under the footrope. The nets were equipped with a second bag hung under the main net to capture animals escaping under the main footrope. The *Arcturus* examined the performance of the 83-112 trawl that is used in the Bering Sea survey and the *Aldebaran* examined the Poly-Nor'eastern bottom trawl used in Gulf of Alaska, Aleutian Island and West Coast surveys. Both data sets are being evaluated at this time, although preliminary evidence indicates that escapement is highly species-specific, as expected.

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

1997 RACE Aleutian Islands Triennial Groundfish Survey

The sixth comprehensive triennial bottom trawl survey of the Aleutian Islands region groundfish resources was conducted from 8 June through 15 August 1997 by the RACE Division. Sampling was conducted aboard two chartered commercial trawlers over a 70-day period. The survey was divided into three legs of 23-24 days each. Sampling began on the north side of the Aleutian Islands between Unimak Pass (165°W long.) and the Islands of Four Mountains (170°W long.) and extended westward throughout the remainder of the Aleutian Archipelago to Stalemate Bank (171°E long.). We sampled pre-selected stations or nearby alternate stations in depths between 22 m and 501 m.

The primary focus of these ongoing triennial groundfish surveys is to build a standardized time series of data to assess, describe, and monitor the distribution, abundance, and biological condition of groundfish stocks in the Aleutian Islands region. Previous comprehensive AFSC surveys in this region occurred in 1980, 1983, 1986, 1991, and 1994. Specific objectives of the 1997 triennial survey were to describe the distribution and relative abundance of the principal groundfish and commercially important invertebrate species that inhabit the Aleutian region; estimate the absolute abundance of the principal groundfish species; collect biological data to describe the age, sex, size, growth rates, length-weight relationships, feeding habits, and taxonomy of various species. During this survey we also tested the feasibility of using trawls equipped with specialized footropes (tire gear) to assess areas we had been unable to sample previously due to rough bottom terrain.

Both vessels used RACE-standardized Poly-Nor'eastern high opening bottom trawls, rigged with roller gear 24.2 m long and constructed of 1.9 cm diameter 6 x 19 galvanized steel wire rope and 36 cm rubber bobbins separated by a solid string of 10 cm rubber disks. One slightly reinforced Poly-Nor'eastern net was equipped with tire gear to test its ability to sample sites in rugged bottom areas.

The Aleutian Islands region is characterized by a relatively narrow continental shelf crossed by numerous deep passes. Very strong currents flow through the passes and across the shelf, making productive fishing operations difficult. Heavy currents often caused work to be halted or postponed. Commercially valuable roundfish such as Atka mackerel; Pacific cod; walleye pollock; sablefish; flatfish (primarily, Pacific halibut and Greenland turbot); rockfish species including Pacific ocean perch, rougheye and shortraker rockfishes; and invertebrates

including golden king crab and scallops inhabit the area. The rocky bottom conditions provide abundant substrate for many species of bryozoans, sponges and corals.

Standard trawl hauls were 15 minutes in actual on-bottom duration. Trawl time on bottom was determined using acoustic net mensuration equipment, bottom contact sensors, and a bathythermograph. Catches were sorted to species, weighed, and enumerated. Biological data, including age structures (otoliths), lengths, and weights of individual specimens were collected from major species caught in each haul. Water column temperature profiles were recorded at most stations using a headrope-mounted bathythermograph.

Successful tows were performed at 404 of the 441 sites where tows were attempted. An additional 41 successful tows using the experimental tire gear footrope were completed throughout the survey area. The results from the tows made with the tire gear were not pooled with the regular survey tows. Preliminary biomass estimates indicate that Pacific ocean perch was by far the dominant groundfish species in the survey area (732,000 t) followed by Atka mackerel (476,000 t) and walleye pollock (206,000 t)(Table 1). Other abundant groundfish species included arrowtooth flounder (94,000 t), Pacific cod (90,000 t), northern rockfish (81,000 t) and Pacific halibut (69,000 t). A comparison of the abundance estimates from the 1994 and 1997 Aleutian Islands triennial surveys appears in Table 1.

Table 1.--Biomass estimates for selected groundfish species based on the 1994 and 1997 Aleutian Islands triennial surveys.

Species	1994	1997	Percent Change
Arrowtooth flounder	72,093	94,118	30.6
Kamchatka flounder	55,140	42,785	-22.4
Greenland turbot	29,104	32,027	10.0
Pacific halibut	62,747	68,883	9.8
Rock sole	55,997	56,228	0.4
Pacific cod	195,382	89,784	-54.0
Walleye pollock	154,769	205,766	33.0
Atka mackerel	719,766	476,039	-33.9
Shortspine thornyheads	7,297	10,595	45.2
Rougheye rockfish	15,156	12,770	-15.7
Pacific ocean perch	447,146	731,813	63.7
Northern rockfish	82,498	80,999	-1.8
Shortraker rockfish	29,408	40,883	39.0

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

1997 RACE West Coast Continental Slope Bottom Trawl Survey

The RACE West Coast Groundfish Team conducted 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 (34°50'N lat.) in waters 183-1,280 m deep from 20 October to 25 November aboard the NOAA ship *Miller Freeman*. This was the tenth survey in an ongoing series to monitor long-term trends in the distribution and abundance of WCUCS groundfish populations. Resource information for management purposes is needed for several WCUCS species including sablefish, shortspine thornyhead, longspine thornyhead, and Dover sole. The survey area was expanded this year to cover a much broader section of the West Coast compared to prior years when only different contiguous sections were trawled each year. In order to complete the survey in the given amount of time, we reduced the sampling density by one-third. It was also the third consecutive year that the WCUCS groundfish trawl survey used slight modifications in trawl gear and towing protocol. Instituted in 1995, these changes refined the level of standardization of our sampling techniques and helped to stabilize gear performance.

The 1997 survey successfully sampled 182 of 200 planned stations along 31 east-west tracklines spaced 50 km apart between lat 48°05'N and 34°50'N lat. Pacific hake and spiny dogfish had the highest mean catch rates in the two shallowest depth strata (183-549 m), and longspine thornyhead, Dover sole, Pacific grenadier, and sablefish were among the fish species with the highest mean catch rates in the deepest 4 strata.

These surveys provide information to fisheries managers and the fishing industry on the abundance, distribution, and biological characteristics of groundfish resources of the northeastern Pacific Ocean upper continental slope between the U.S.-Canada border and central California. A complete set of analyses including descriptions of species' distribution and estimates of their abundance (biomass and numbers), size, and age composition have been forwarded to authors developing stock assessments of these groundfish resources.

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

REFM Age and Growth Task

The Age and Growth Task of the REFM Division serves as the Alaska Fisheries Science Center's ageing unit for groundfish species. The task 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 task are used in stock assessment work 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 miscellaneous sole and rockfish species.

Craig Kastelle is continuing his ongoing study on the ageing of several rockfish species: Pacific ocean perch, shortspine thornyheads, shortraker, rougheye, northern and dusky rockfishes.

Although the results are somewhat mixed, taken as a whole they generally confirm the strategy of using broken and burnt otoliths for ageing these species. A draft of this study is being finalized for the 'Fish Research and Application' symposium to be held in Bergen, Norway, June 1998. Still continuing is a study with the NMML to apply radiometric ageing to gray and bowhead whales. Results from these studies have some puzzling aspects and are continuing to be evaluated. The work with the whales is difficult and ground breaking, so problems are to be expected.

Delsa Anderl is also continuing to work with Jon Heifetz (ABL) on a study based on known-age sablefish. As part of this study, edge growth increments are being measured on several hundred otoliths.

Nancy Roberson is working on a thesis to help unravel the long-term problems that we have had with the ageing of Pacific cod. She will concentrate on otolith growth patterns found in strong year-classes and try to infer from this the problems with current ageing criteria. A few otoliths from tagged Pacific cod are also available for analysis.

The ageing unit has hired Debbie Nebenzahl, who recently completed a M.S. degree from San Francisco State University and Moss Landing. Her thesis work was on the ageing of Pacific jack mackerel.

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

REFM Resource Ecology and Ecosystem Modeling

The Resource Ecology and Ecosystem Modeling Task continued regular collection of food habits information on key fish predators in the North Pacific. Program personnel, fishery observers, and others collected fish stomachs for the group. About 9,261 stomachs were collected from the Bering Sea, 3,327 from the Gulf of Alaska/Aleutian Islands, and about 2,262 from the West coast region. Bering Sea species sampled were walleye pollock, Pacific cod, yellowfin sole, Alaska plaice, rock sole, flathead sole, skates, arrowtooth flounder, Greenland turbot, Pacific halibut, and sculpins. Gulf of Alaska/Aleutian Island species sampled included walleye pollock, Pacific cod, arrowtooth flounder, Pacific halibut, sablefish, Atka mackerel, Pacific ocean perch, skates, great sculpin, myctophids, Greenland turbot, shortraker rockfish, and prowfish. Pacific hake, Pacific grenadier, and giant grenadier stomachs were collected from the West coast region. Shipboard scans of fish stomach contents were not performed this year. Laboratory analysis of stomach contents by region totaled 2,401, 4,040 and 2,252 stomachs for the Bering Sea and Gulf of Alaska/Aleutian Island, and West coast regions, respectively.

The multispecies virtual population analysis (MSVPA) model, as currently parameterized for the eastern Bering Sea, includes the following species as predators: walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, arrowtooth flounder, and northern fur seal. Arrowtooth flounder and northern fur seals are entered as other predators, which means that VPAs are not performed for these species. Instead, inputs on their consumption rates, diet, and population abundance are input so that their predation on VPA prey species in the model can be calculated. Prey species are walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, rock sole, and

Pacific herring. The modeled time period is 1979 to 1995 and we have included an extensive amount of diet data from close to 40,000 stomach samples collected during that time period. The last few months have been spent adding arrowtooth flounder and northern fur seals to the model, adding substantial amounts of diet data, and updating and re-tuning the VPA inputs to reflect the most recent assessment data. The single-species VPAs have been tuned to fit the outputs of the more complex stock assessment models that are presently being used for most groundfish species in the eastern Bering Sea.

Model results show that most predation mortality for the prey species in the model (walleye pollock, Pacific cod, Greenland turbot, yellowfin sole, rock sole, and Pacific herring) occurs on juveniles that have not yet recruited to the fishery. Model estimates of population abundance for exploited ages of each prey species are similar to those provided by single species models. However, abundance estimates of juveniles, particularly walleye pollock, are substantially larger than estimates from single-species models. Walleye pollock was the main prey species consumed by MSVPA predators, and cannibalism constituted the majority of the predation mortality of age-0 fish. The dominant predators on age-1 pollock included adult pollock, Pacific cod, arrowtooth flounder, and northern fur seals. In some years, Pacific cod consumed the largest biomass of walleye pollock prey relative to other predators. However, most of the biomass of pollock consumed by cod tended to be from older pollock age groups.

A sensitivity analysis of the MSVPA model is currently underway. Further explorations with the model include: testing the stability of suitability estimates of the model and performing multispecies forecasts using various management scenarios.

Groundfish Predation on Walleye Pollock Around Frontal Regions in the Eastern Bering Sea

Walleye pollock serve as an important forage fish in the eastern Bering Sea ecosystem. As part of an ongoing study of the processes affecting juvenile walleye pollock recruitment in the eastern Bering Sea, a concentrated effort has been focused on the hydrographic fronts near the Pribilof Islands, Alaska, as an important nursery area for these juveniles. Diel variation in the consumption of age-0 walleye pollock by arrowtooth flounder was examined at a series of stations at the tidal front located north of St. Paul Island, Alaska. Age-0 walleye pollock were the primary prey of arrowtooth flounder throughout the day, but were least digested in the late day indicating a diurnal feeding pattern. A similar diurnal pattern was not seen in the distribution of age-0 walleye pollock suggesting that feeding pattern exhibited by arrowtooth flounder was based upon their behavior. Lengths of age-0 walleye pollock consumed by arrowtooth flounder were similar to those sampled from mid-water trawls. Walleye pollock cannibalism was examined along a transect that included samples collected at the front and offshore of the front. Age-0 walleye pollock were the primary prey (by weight) of walleye pollock at all locations. Adjacent cohort cannibalism was prevalent (age-0 walleye pollock were 79% of the diet by weight) at the frontal region. Cannibalism rates on age-0 walleye pollock were highest at the front for age-1 walleye pollock and offshore for the adult pollock. Prey selectivity analysis indicated that age-0 walleye pollock were more highly selected offshore than at the front.

PICES Climate Change and Carrying Capacity Program

The PICES-GLOBEC Climate Change and Carrying Capacity Program chaired by Patricia Livingston (AFSC) and Yutaka Nagata is now moving away from a planning phase and is beginning to undertake cooperative research activities. Three of our Task Teams (BASS, MODEL, and REX) have held workshops or symposia to outline the current state of knowledge in their area of interest and to identify areas for cooperative research experiments in support of the CCCC Program. The cooperative projects that have been identified are in various stages of implementation and we have a new task team, MONITOR, formed at the last annual meeting that will be just beginning to define its program of work in the coming year.

MODEL Task Team (co-chairmen: Ian Perry and Sinjae Yoo) held a workshop in Nemuro, Japan, in June 1996, to review the roles and limitations of modeling for the CCCC Program, propose the level of modeling required, and provide a plan for how to promote these modeling activities. The results and recommendations of this workshop have previously been reported (PICES Press, vol. 4 No. 2; PICES Scientific Report No. 7, 1997). Since the workshop, MODEL has been refining its role in the CCCC Program and has developed the following approach. The task team recognized that many modeling activities are already taking place regarding North Pacific physics and biology. But what seems to be lacking is the awareness and communication among these activities, and the possible linkages among physical and biological modelers, and the awareness and communication with field programs. Therefore, the primary role of MODEL is to:

- Facilitate communication among modeling studies and with field programs;
- Identify and stimulate areas of modeling that are significant to the CCCC Program but which are not presently addressed; and
- Assist other task teams of the CCCC Program (e.g., REX, BASS) with model-related needs.

MODEL has recently completed several activities related to these goals. In the past year, an opportunity to explore simple mass-balance models was presented and a topic session on "Models for Linking Climate and Fish" was convened at the PICES Sixth Annual Meeting. In addition, North Pacific circulation modelers were contacted to explore possibilities of making model results widely available to the PICES community. An inventory and description of these North Pacific circulation models have been prepared, which includes contacts for access to results. This information will soon be available on a page within the PICES web site or by request to the Secretariat. In 1998, it is planned that this web page will be expanded to include biological models and modeling activities in the PICES areas, to serve as an information exchange for North Pacific modeling activities. Another hoped-for addition to the web page is an inventory of important but often missing components of models, such as parameterization of vertical mixing and diffusion and representations of vertical migration by zooplankton.

MODEL will be convening a small workshop in 1998 to compare lower trophic level physiological models. The purpose of this workshop is to facilitate standardization or intercalibration of these process models in order to aid comparison of ecosystem responses. It is

also hoped that a nutrient database will be assembled at this workshop for modeling new production in PICES regions.

REX (**R**egional **EX**periment) Task Team (co-chairmen: Anne Hollowed (AFSC), Vladimir Radchenko, and Tokio Wada) convened a workshop 17-18 October 1997, just prior to PICES VI in Pusan, Korea. The purpose of the workshop was to review the status of national research programs and to identify areas for cooperative research experiments in support of the CCCC Program. Over 50 scientists participated in the workshop, representing approximately 40 research institutions. The focus of the workshop was to examine the possibility of applying the comparative approach to address the Central Scientific Issues identified by the Program. The workshop began with a review of the GLOBEC and GLOBEC-like research programs planned or on-going in each of the six PICES member nations. Subsequently, participants discussed coastal research programs in breakout sessions targeting forcing, lower trophic level response, higher trophic level response, and ecosystem response. A complete summary of the workshop proceedings and all of its recommendations will be published later this year in the PICES Scientific Report Series. Workshop recommendations that the team has adopted for the near future include:

- PICES member nations should compile a catalogue of historical samples and data sets which are not yet analyzed or readily available;
- Issues of standardization of sampling and analysis methods for comparative studies should be addressed;
- A two-day symposium and workshop on climate effects on small pelagic species should be convened prior to the PICES Seventh Annual Meeting in Fairbanks, Alaska; and
- A scientific session that highlights research findings of GLOBEC and GLOBEC-like programs in the North Pacific should be convened as part of the PICES Seventh Annual Meeting.

BASS (**BA**sin Scale Studies) Task Team (co-chairmen: Dick Beamish, Makoto Terazaki) took a large step forward this year to meet the challenge of identifying comparative research projects in the North Pacific subarctic gyres. In order to develop plans for intensifying research in the subarctic gyres of the northern North Pacific, BASS considered it desirable to review present scientific knowledge of these features, with particular attention being given to comparisons of the eastern and western sides of the ocean basin. For this purpose, a symposium was organized for PICES VI in Pusan on "Ecosystem dynamics in the eastern and western gyres of the subarctic Pacific." Nine invited papers were scheduled, beginning with climate and oceanic forcing of these systems and to include the several trophic levels from phytoplankton and nutrient dynamics to sea birds and mammals. Conveners were R. Beamish (Canada), M. Terazaki (Japan), S. Kim (Korea), and W. S. Wooster (USA). The presentations were followed by a discussion session in which speakers set forth their views on desirable future research. There were several recommendations on modeling and physical oceanographic research that involved mixed layer dynamics. Particularly, the importance of more small scale examination of the mixed layer, models which consider day-to-day variability in the mixed layer, and information on regional, seasonal, and

interannual variation in mixed layer depth were cited as important research issues. Ocean chemistry and primary production research speakers emphasized the importance of understanding the role of iron in influencing productivity and of understanding mechanisms of nutrient transport into the area. There were a number of research recommendations involving zooplankton but one that has the most potential for comparative study was the suggestion of expanding the comparisons between eastern and western gyres to include zooplankton species composition, seasonal timing and study of life history strategies. Monitoring zooplankton species composition and examining macrocrustacea with single annual breeding seasons were also suggested areas of research. Areas that needed further study with regard to upper trophic level animals, including fish, seabirds and marine mammals, included obtaining seasonal distribution and abundance of fish inhabiting surface waters, standardization (or intercalibration) of methods for studying and sampling midwater fish, and updating databases of seabird distribution in the North Pacific.

BASS Task team also initiated some activities regarding study of the 1997/1998 El Niño. They proposed a symposium to be held in 1998 at PICES VII in Fairbanks, Alaska, to provide opportunities for researchers to present initial research findings of impacts from this event. After this preliminary opportunity to present research, it is hoped that there will be another symposium to be held sometime in 1999, to provide opportunities for more complete reporting of impacts.

The formation of a new MONITOR Task Team was approved at PICES VI in Pusan, Korea. The terms of reference for the new task team are:

- Review existing activities of PICES member nations and to suggest improvements in the monitoring of the Subarctic Pacific to further the goals of the CCCC Program.
- Consult with REX, BASS and MODEL Task Teams and TCODE on the scientific basis for designing the PICES monitoring system. Questions of standardization and intercalibration of measurements, particularly in the area of biological collections, should be addressed.
- Assist in the development of a coordinated monitoring program to detect and describe events, such as El Nino, that strongly affect the Subarctic.
- Report to CCCC IP/EC on the monitoring in the Subarctic to be implemented in the international Global Ocean Observing System (GOOS) or other related activities.

The co-chairmen of MONITOR will be Drs. Yasunori Sakurai and Bruce Taft. The rest of the Task Team members will be selected early this year and plans for implementing their terms of reference will begin.

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

Multispecies Studies (Stock Assessment)

REFM Status of Stocks and Multispecies Assessment Task

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) provided analysis to the National Research Council for the national review of stock assessment methods, 5) provided analysis of environmental impacts of the pollock and Atka mackerel fisheries on Steller sea lions, and 6) worked with the NMFS Alaska Regional Office 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; provided information and advice on identification and description of essential fish habitat; 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.

Multispecies Studies (Management)

REFM North Pacific Groundfish Observer Program

The North Pacific Groundfish Observer Program is responsible for placement of observers on vessels fishing for groundfish species in the 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 continuation of the U.S. fishing industry.

During 1997, 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 498 observers to vessels fishing off Alaska, and 20 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.

Throughout 1997, the Observer Program has continued to develop and change its information systems. One significant change involves the development of an electronic reporting system to transmit observer sampling data from sea, which was implemented in 1997. This system increases efficiency and accuracy of data transmission by eliminating the need for observers to summarize, code, and format their data into catch messages. It also allows for rapid communications between observers and NMFS staff. This provides the Observer Program with an improved ability to solve problems which observers encounter at sea and substantially shortens the debriefing process.

Fieldwork for a research project designed to evaluate Observer Program procedures for estimation of total catch weight was completed in March 1997. The objectives of the research project were as follows:

- Evaluation of the accuracy of volume-based methods of catch weight determination by comparison of estimates obtained from these procedures with weight estimates obtained from a flow scale.
- Determination of accurate in situ fish density factors to use in volume-to-weight conversions in the Bering Sea pollock fisheries.
- Determination of the accuracy of the flow scale used in this study and evaluation of proposed test procedures for monitoring flow scale performance.
- Evaluation of the use of ultrasonic bin sensors for determining fish volumes in holding bins.

The results of this project can be found in AFSC Processed Report 97-07, "Evaluation of Haul Weight Estimation Procedures Used by At-sea Observers in Pollock Fisheries off Alaska."

At its December 1997 meeting, the North Pacific Fishery Management Council (NPFMC) requested that NMFS continue working on a joint partnership agreement with the Pacific States Marine Fisheries Commission (PSMFC) to provide observer procurement services. Under this modified pay-as-you-go Observer Program, PSMFC would act as an interface between observer companies and vessels or shoreside plants required to carry observers. This would resolve some conflict of interest issues, allow for potential increases in observer compensation, and address concerns regarding supervision of observer companies.

Also, at its December 1997 meeting, the NPFMC requested that NMFS begin work again on a fee-based observer procurement system (previously referred to as the "Research Plan"). Under this system, which is authorized in the Magnuson-Stevens Fishery Conservation and Management Act, vessels and processors participating in halibut, crab, and groundfish fisheries in the EEZ off Alaska would pay up to 2% of the landed value of their catch. This money would be used to procure and deploy observers consistent with coverage requirements.

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

REFM Socioeconomic Assessment Task

From May 1997 through April 1998, the Socioeconomic Assessment Task 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. Task members served on the BSAI, 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) NPFMC increased retention and utilization program for the Alaska groundfish fisheries, 2) NPFMC individual vessel bycatch allowance program for the Alaska groundfish fisheries, 3) allocation of the BSAI pollock quota among factory trawlers, motherships and on-shore processors, 4) the expansion of the community development quota (CDQ) program to all BSAI groundfish and crab fisheries, 5) cost recovery program for the Alaska IFQ and CDQ programs, and 6) PFMC fixed gear sablefish fishery management. Another activity task members contributed to in support of the NPFMC was the implementation of a program to collect cost, earnings and employment data and develop models to use that data to measure the economic performance of the Alaska groundfish and halibut fisheries. Task members have participated in a similar program for the PFMC fisheries.

Task members prepared publications on the following topics: 1) bycatch management, 2) the economic status of the Alaska groundfish fisheries, 3) the exports of edible fishery products from the Pacific Northwest and Alaska, 4) global fishery and trade policy, 5) cooperative fishing arrangements in the EEZs, 6) the economic aspects of the BSAI pollock fisheries, 7) improved retention and utilization, 8) modeling fleet behavior, 9) U.S. fishery management, and 10) international coordination and cooperation for effective management.

Task members provided economic advice, technical review and support for: 1) Saltonstall-Kennedy and Sea Grant research proposals, 2) the development of the AKFIN system, 3) NMFS

limited access workshops, 4) the development of a NMFS bycatch plan, 5) the development of guidelines for new national standards and authority under the Magnuson-Stevens Act, 6) the National Research Council review of IFQ programs, 7) NMFS economists' meeting at the Northeast Fisheries Science Center, 8) development of NMFS strategic plan for research and performance measures, and 9) the ICES Study Group on the Management Performance of Individual Transferable Quota Systems.

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

Pacific Cod Stock Assessment

Bering Sea/Aleutian Islands

The present assessment is a straightforward update of last year's assessment, incorporating new catch and survey information into a length-based synthesis model. This year's eastern Bering Sea bottom trawl survey resulted in a biomass estimate of 605,000 t, a 32% decrease relative to last year's estimate. This year's Aleutian bottom trawl survey resulted in a biomass estimate of 74,700 t, a 49% decrease relative to the 1994 estimate. These declines are roughly consistent with the downward trend projected in last year's assessment. The assessment model projects the 1998 age 3+ biomass at 1,340,000 t. Last year, the North Pacific Fishery Management Council's Scientific and Statistical Committee (SSC) determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that Pacific cod therefore qualified for management under tier 3 of Amendment 44. The updated point estimates of $B_{40\%}$ (measured in units of spawning biomass), $F_{40\%}$, and $F_{30\%}$ from the present assessment are 352,000 t, 0.29, and 0.42, respectively. Projected spawning biomass for 1998 is 383,000 t, placing Pacific cod in sub-tier "a" of tier 3 since the estimated current spawning biomass is above the $B_{40\%}$ level. The assessment authors' recommendation of a 1998 ABC of 210,000 t 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 catch corresponds to a fishing mortality rate of 0.25, below the $F_{40\%}$ point estimate of 0.29 which constitutes the upper limit on F_{ABC} under tier 3a. The OFL (overfishing level) was determined from the tier 3a formula, where an $F_{30\%}$ value of 0.42 gives a 1998 OFL of 336,000 t.

Gulf of Alaska

As in the Bering Sea assessment, a length-based synthesis model is used which indicates the exploitable biomass of Pacific cod increased from 650,000 t in 1997 to 785,000 t projected for 1998. Similar to last year, the author provided a comprehensive analysis on the affect of uncertainty in the natural mortality rate and survey catchability. This year the author also included length frequency and landings data from Pacific cod harvests in the State of Alaska fishery. From these the author derived a risk-averse level of ABC levels. This analysis provided a decision

theoretic perspective which is preferable to using ad-hoc methods (such as setting ABC to the value that corresponds to the lower 95% confidence bounds). The Groundfish Plan Team acknowledged that given the complicated technical aspects of the Gulf of Alaska Pacific cod model, particularly in developing a realistic posterior probability density estimate, it may be difficult in future years to base ABC recommendations on a similar risk-averse strategy.

The $F_{40\%}$ yield for 1998 would be 96,700 t under tier 3a. However, given the risk-averse analysis as presented, the author's recommendation was used to set ABC equal to 77,900 t. The breakdown of ABC to Western, Central, and Eastern Gulf regions would be 27,260 t, 49,080 t, and 1,560 t, respectively. The overfishing level of 141,000 t is based on the $F_{30\%}$ harvest guideline.

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

Shelf Rockfish Stock Assessment

Gulf of Alaska

Pelagic Shelf Rockfish

The pelagic shelf rockfish assemblage has been comprised of five 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 appears to be the most abundant species in the group, and has been the target of a bottom trawl fishery since the late 1980s. An important management change regarding this assemblage occurred in February 1998, when final approval was given to a management plan amendment that separated black rockfish and blue rockfish from the pelagic shelf group. The amendment also transferred management authority for these two species from the Federal Council process to state of Alaska jurisdiction. The inclusion of black rockfish in the pelagic shelf assemblage had resulted in localized management problems for these fish over the past several years, and their transfer to state authority will hopefully remedy this situation.

ABC in 1998 for the remaining three species of the assemblage is calculated using the same procedure as that applied to the old assemblage in previous years. Gulfwide exploitable biomass is based on the average of the biomasses estimated in the 1990, 1993, and 1996 triennial trawl surveys: 55,583 t. 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 5,000 t for 1998.

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

Slope Rockfish Research

Gulf of Alaska

Electrophoretic Studies of Rougheye and Shortraker Rockfish

ABL's genetics task has completed allozyme analysis from 800 rougheye rockfish, and 650 shortraker rockfish collected in the eastern, central, and western Gulf of Alaska, the Aleutian Islands, and northern Kamchatka, Russia. The purpose of the study is to investigate the geographic stock structure of rougheye and shortraker rockfish. Of the 47 enzymes screened, 23 were resolved for a total of 30 loci. No heterogeneity was detected Gulfwide among the shortraker rockfish collections. Significant heterogeneity was detected for rougheye rockfish between the eastern Gulf of Alaska and the central Gulf of Alaska-Aleutians-Kamchatka region. This heterogeneity is attributed to the finding of two distinct genetic "types" among the rougheye rockfish, perhaps even sibling species. The two types were found sympatrically, though one type was found exclusively in the Aleutian Islands and northern Kamchatka, and dominantly in the central Gulf of Alaska, while the other type dominated in the eastern Gulf of Alaska. Further collections of rougheye rockfish in more southerly waters (southern British Columbia, Washington State, and the Kuril Islands, Russia) are currently underway in order to ascertain the range of the two genetic "types", and to conduct a possible morphological study.

For more information, contact Sharon Hawkins (907)789-6081 or Jon Heifetz (907)789-6054.

Adaptive Sampling of Slope Rockfish

In cooperation with the Juneau Center, School of Fisheries and Ocean Sciences at the University of Alaska Fairbanks (UAF), ABL scientists have initiated a 2-year study to evaluate a new survey method specifically designed for slope rockfish. This study was selected for funding under the Sea Grant - NOAA Partnership National Strategic Initiative competition. The study will focus on three commercially important species of slope rockfish: Pacific ocean perch, shortraker rockfish, and rougheye rockfish. The net used will be equipped with "tire gear" to facilitate trawling over rough substrate, and a new survey design, adaptive sampling, will be investigated. Scientists from ABL, RACE, and REFM divisions are participating in the planning and field data collection for this study. For the 1998 study, a chartered commercial trawling vessel will be used for a period of 17 days in July and August in waters near Kodiak Island, Alaska.

Adaptive sampling is a relatively new technique which, to date, has been little used in fisheries applications. This sampling method appears to be particularly appropriate for populations with a clustered distribution, such as that observed for Pacific ocean perch. An application of adaptive sampling to larval fish populations by scientists at the Southwest Fisheries Science Center resulted in increased survey precision as well as information about the dimension of egg and larval patches. In adaptive sampling, random or systematic sampling is initially used to

locate concentrations of the targeted species, and is then followed by intensive sampling in the vicinity of the concentrations. A brief adaptive sampling experiment for Pacific ocean perch was conducted in April 1996 using the NOAA ship *Miller Freeman*, and it indicated that adaptive sampling may have benefits over random sampling in assessment surveys for rockfish. The 1998 study will be a follow-up to the 1996 work, but will be much expanded in duration and area, so that a comprehensive evaluation of the adaptive sampling methodology can be made.

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

Species Identification of Rockfish Larvae

ABL scientists, in cooperation with Dr. Anthony Gharrett and Andrew Gray of the University of Alaska Fairbanks, are working on identification of preflexion rockfish larvae using digital camera recorded pigment patterns and mitochondrial DNA (mtDNA) techniques to confirm species identifications. Preliminary experiments in May 1996 showed that single preflexion larvae could be identified using mtDNA at a smaller size than possible with allozyme techniques. In a July 1997 cruise in southeastern Alaska, more than 172 rockfish preflexion larvae were photographed, of which 34 were subjected to mtDNA analyses. Seven species of rockfish associated with 12 pigment patterns were identified, including *Sebastes maliger*, *S. ciliatus*, *S. proriger*, *S. ruberrimus*, *S. borealis*, *S. variegatus*, and *S. zacentrus*. As the database grows, plans are to describe the variability of larval pigment patterns within a species and how pigment patterns change with growth. In 1998, the study will hopefully be expanded to include postflexion larvae and additional species. The results of the program were presented at the Tenth Western Groundfish Conference in Asilomar, California, in February 1998.

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

Submersible Observations of Longline Survey Catch Process for Shortraker and Rougheye Rockfish

Submersible observations of the longline gear used in the annual AFSC longline survey were completed during a 2-week period in August 1997. These observations add to observations completed in 1994. The purpose of this study is examine local depletion by the longline gear and to estimate a catchability coefficient for shortraker and rougheye rockfish caught on the gear. The longlines were set by the F/V *Ocean Prowler* and observed from the manned submersible *Delta*, which was deployed from the M/V *Cavalier*.

For more information, contact Dr. Michael Sigler (907)789-6037, Ken Krieger (907)789-6053, or Dan Ito (206)526-4231.

Slope Rockfish Stock Assessment

Bering Sea

The POP complex consists of true Pacific ocean perch — 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 Pacific ocean perch separately from the other species in both areas, and has also split out rougheye and shortraker in the Aleutian Islands. 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 Aleutian Islands 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 includes several changes from last year's assessment, incorporating new catch information as well as changes in other model inputs and model structure. In terms of model inputs, one change was the replacement of the time series of EBS trawl survey (slope and shelf combined) biomass estimates with a single average value. In terms of model structure, this year's assessment includes a decreased emphasis on fitting the biomass estimate from the EBS trawl survey and a decreased emphasis on fitting the fishery size composition data. The net effect of all of the above changes is a decrease in biomass estimated by the present model. Last year, the North Pacific Fishery Management Council's SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock and that true POP in the EBS therefore qualified for management under tier 3 of Amendment 44. The updated estimates of $B_{40\%}$ (measured in units of spawning biomass), $F_{40\%}$, and $F_{30\%}$ from the present assessment are 34,400 t, 0.058, and 0.083, respectively. Projected spawning biomass for 1998 is 23,900 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:

$$F_{ABC} \le F_{40\%} \times (B_{98}/B_{40\%} - 0.05)/(1-0.05) = 0.058 \times (23{,}900/34{,}400 - 0.05)/0.95 = 0.039$$

However, the assessment authors recommend use of a more conservative value based on an adjusted $F_{44\%}$ (=0.050) rate, where the adjustment is based on the ratio of projected 1998 spawning biomass to $B_{44\%}$ (37,900 t). Specifically, the chapter authors recommend setting F_{ABC} as follows:

$$F_{ABC} = F_{44\%} \times (B_{98}/B_{44\%} - 0.05)/(1-0.05) = 0.050 \times (23{,}900/37{,}900 - 0.05)/0.95 = 0.031$$

Projected harvesting at a fishing mortality rate of 0.031 gives a 1998 ABC of 1,400 t. The OFL fishing mortality rate is computed under tier 3b as follows:

$$F_{OFL} = F_{30\%} \times (B_{98}/B_{40\%} - 0.05)/(1-0.05) = 0.083 \times (23{,}900/34{,}400 - 0.05)/0.95 = 0.056$$

The 1998 OFL of 3,300 t reported in the chapter does not correspond exactly to a fishing mortality rate of 0.056, but it was developed in an analogous fashion and is the best available estimate of OFL at the present time.

True POP, Aleutian Islands:

The present assessment includes several changes from last year's assessment, incorporating new catch and survey information as well as changes in model structure. This year's Aleutian Islands bottom trawl survey resulted in a biomass estimate of 714,000 t, a 69% increase relative to the 1994 estimate. In terms of model structure, this year's assessment includes a decreased emphasis on fitting the biomass estimate from the Aleutian bottom trawl survey, a decreased emphasis on fitting the fishery size composition data, and a new estimate of the trawl survey catchability coefficient (1.77). The net effect of all of the above changes is a decrease in biomass estimated by the present model. Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock and that true POP in the Aleutians therefore qualified for management under tier 3 of Amendment 44. The updated estimates of $B_{40\%}$ (measured in units of spawning biomass), $F_{40\%}$, and $F_{30\%}$ from the present assessment are 127,000 t, 0.068, and 0.096, respectively. Projected spawning biomass for 1998 is 129,000 t, placing true POP in the Aleutians in sub-tier "a" of tier 3. The maximum F_{ABC} value allowed under tier 3a is $F_{40\%}$ (0.068). However, the assessment authors recommend use of a more conservative value based on an adjusted $F_{44\%}$ (=0.060) rate, where the adjustment is based on the ratio of projected 1998 spawning biomass to $B_{44\%}$ (140,000 t). Specifically, the assessment authors recommend setting F_{ABC} as follows:

$$F_{ABC} = F_{44\%} \times (B_{98}/B_{44\%} - 0.05)/(1-0.05) = 0.060 \times (129{,}000/140{,}000 - 0.05)/0.95 = 0.055.$$

Projected harvesting at a fishing mortality rate of 0.055 gives a 1998 ABC of 12,100 t. The OFL was determined from the tier 3a formula, where an $F_{30\%}$ value of 0.096 gives a 1998 OFL of 20,700 t.

Other Members of the POP Complex, Eastern Bering Sea:

The present assessment is a straightforward update of last year's assessment, incorporating new catch data and survey data. This year's Aleutian bottom trawl survey provided estimates of biomass in the small part of the EBS covered by that survey. Traditionally, the biomass estimates from all trawl surveys (both EBS shelf/slope and Aleutian) are averaged over all years to obtain the best estimate of biomass for the species in this subcomplex. Summed over the species in the subcomplex, this procedure produces a biomass estimate of 22,800 t, down 23% from last year's estimate. By species, the biomass estimates are as follows: rougheye rockfish--2,710 t, shortraker rockfish--8,230 t, and northern rockfish--11,900 t. However, the Plan Team was alerted to the fact that one exceptionally large tow of northern rockfish from the 1986 Aleutian trawl survey (in the small part of the EBS covered by that survey) was responsible for approximately 94% of the above estimate of northern rockfish biomass. Eliminating the 1986 Aleutian survey's estimate of northern rockfish biomass in the EBS results in a revised average biomass estimate of 693 t. Last year, the SSC determined that reliable estimates of the natural

mortality rate (M) existed for the species in this subcomplex, and that non-*alutus* members of the POP complex in the EBS therefore qualified for management under tier 5 of Amendment 44. 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 1998 ABC of 267 t. The OFL was determined from the tier 5 formula, where setting F_{OFL}=M for each species gives a combined 1998 OFL of 356 t.

Northern and Sharpchin Rockfish, Aleutian Islands:

The present assessment is a straightforward update of last year's assessment, incorporating new catch and survey data. Because sharpchin rockfish are found only rarely in the Aleutian Islands, northern rockfish are for all practical purposes the only species in this subcomplex. Traditionally, the biomass estimates from all Aleutian bottom trawl surveys are averaged over all years to obtain the best estimate of northern rockfish biomass. This procedure produces a biomass estimate of 94,000 t, down 3% from last year's estimate. 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 Amendment 44. The accepted estimate of M for northern rockfish in the Aleutians is 0.06. The Plan Team recommended 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 1998 ABC of 4,230 t. The OFL was determined from the tier 5 formula, where setting F_{OFL}=M gives a 1998 OFL of 5,640 t.

Shortraker and Rougheye Rockfish, Aleutian Islands:

The present assessment is a straightforward update of last year's assessment, incorporating new catch data and survey data. Traditionally, the biomass estimates from all Aleutian bottom trawl surveys are averaged over all years to obtain the best estimate of biomass for the species in this subcomplex. Summed over the species in the subcomplex, this procedure produces a biomass estimate of 46,500 t, up 2% from last year's estimate. By species, the biomass estimates are as follows: rougheye rockfish--21,600 t and shortraker rockfish--24,900 t. Last year, the SSC determined that reliable estimates of the natural mortality rate (M) existed for the species in this subcomplex, and that shortraker and rougheye rockfish in the Aleutians therefore qualified for management under tier 5 of Amendment 44. 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 1998 ABC of 965 t. The OFL was determined from the tier 5 formula, where setting F_{OFL}=M for each species gives a combined 1998 OFL of 1,290 t.

For further information, contact Daniel Ito (206)526-4231.

Gulf of Alaska

Slope rockfish are defined as those species of *Sebastes* that, as adults, inhabit waters of the outer continental shelf and continental slope of the Gulf of Alaska, 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 fifth triennial trawl survey of the Gulf of Alaska was completed in 1996, and it showed a substantial increase in biomass of Pacific ocean perch. This increase follows another large increase in biomass seen in the previous trawl survey 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, our best estimate of exploitable biomass for Pacific ocean perch in the Gulf of Alaska is now 243,170 t, similar to last year's estimate of 242,300 t. Exploitable biomass for the other species in the assemblage is estimated from the average values in the 1990, 1993 and 1996 trawl surveys, and totals 252,460 t. Unlike Pacific ocean perch, survey biomass estimates for the other species have generally not shown large increases in recent years.

Pacific ocean perch age samples indicate the presence of a strong 1986 year class, especially in the central and western Gulf of Alaska. This year class was first noted in samples from the 1990 triennial survey and verified in the 1993 survey. Past age samples have also identified a strong 1976 year class. Age composition from the 1996 survey has not been incorporated into the current assessment model.

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. 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 1998 ABCs are as follows: Pacific ocean perch, 12,820 t; shortraker/rougheye rockfish, 1,590 t; northern rockfish, 5,000 t, and other slope rockfish, 5,260 t.

In 1993, a rebuilding plan was initiated for Pacific ocean perch. Under this plan, an $F_{55\%}$ rate adjusted downward by ratio of current biomass to target biomass was used to compute a Total Allowable Catch (TAC) for Pacific ocean perch. However, the most recent assessments have indicated that the objectives of the rebuilding have been met.

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

West Coast

Pacific Ocean Perch

This assessment will be updated in May 1998; the following description is the current state of the knowledge of the stock. A rebuilding program was established for Pacific ocean perch in 1981 following depletion of this stock during the 1960s and early 1970s. The latest stock assessment, conducted for POP in 1995, recommended the ABC in the Columbia-Vancouver areas remain at zero in order to continue the rebuilding program. The average 1989-93 landed catch of 1,246 t exceeded the level of overfishing and probably has inhibited rebuilding of this stock. The 1994 landed catch was reduced to 953 t and the catch in 1995 was about 850 t. The stock's current potential egg production is only about 15% of the expected unfished level and less than 50% of the target level. Stock projections under random average recruitment scenarios indicate that the current abundance is lower than any expected under an $F_{35\%}$ exploitation rate. The degree to which the low level of spawner abundance inhibits attainment of random average recruitment levels is not known. Maintaining the stock at this low level increases the risk of further stock collapse if a long series of poor recruitments occur. Rebuilding of the Pacific ocean perch stock to its target level of abundance would result in doubling the current biomass. This will be a slow process unless there is a fortuitous sequence of large recruitments. A rebuilt Pacific ocean perch stock will support an average annual harvest of about 1,000 t. Thus the rebuilding plan might be restated as: a decrease in annual catch to much below the recent 1,200 t level in order to encourage stock rebuilding, so that a similar level of catch can be obtained in the long-term while fishing at a lower and safer exploitation rate.

The 1996 *Sebastes* complex assessment included an estimate of the Pacific ocean perch population size in the southern areas. The estimate is based on the assumptions that the NMFS triennial shelf survey for groundfish provides a valid relative index of abundance for this species and that fishing mortality = natural mortality is a reasonable harvest policy for Pacific ocean perch. The assessment suggests that an ABC of 20 t is appropriate for this stock.

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

Thornyheads Stock Assessment

Gulf of Alaska

Shortspine thornyheads were assessed using a slightly different model than in past assessments. Key changes in model structure include assuming a trawl survey catchability of 1.0 for the years when the survey included the deeper waters of the Gulf, and estimating the value for the recent survey years. Rather than fixing natural mortality at some alternative values, the assessment authors assumed a prior distribution for M. Also, annual fishing mortality was reported differently than in the past. In this model, the annual fishing mortality rates are given as the average rate over all ages. This contrasts with the "full-selection" values that have become

commonly reported in recent years. The model estimated a 1998 biomass of 52,271 t, an increase from the 46,108 estimated from last year's assessment. The Plan Team requested a conversion between the "average" $F_{40\%}$ (and $F_{30\%}$) value and the corresponding "full selection" values as:

	Average F	Full-selection F
$F_{40\%}$	0.042	0.080
$F_{30\%}$	0.061	0.115

The assessment recommended an ABC value of 2,000 t and an OFL level of 2,840 t. The ABC recommendation is based on the $F_{40\%}$ harvest rate assuming a 50:50 split of the catch between trawl gear and longline gear, which is similar to the recent observed catch. The ABC was apportioned by area to reflect the survey biomass distribution. This resulted in an apportionment as follows:

	Western	Central	Eastern
Wtd. Avg.	13%	36%	51%
ABC	250	710	1,040

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

Sablefish Research

Gulf of Alaska

Sablefish Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in Alaska from 1987 to 1997. 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 to 1994 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 1997. In 1997, 73 stations were sampled in the Gulf of Alaska and 16 stations were sampled in the eastern Bering Sea from 21 May to 31 August. Sixteen kilometers of groundline are set each day, containing 7,200 hooks baited with squid, except in the eastern Bering Sea, where 8,100 hooks are set. More hooks are set in the eastern Bering Sea to better sample Greenland turbot. The survey vessel was the chartered fishing vessel *Ocean Prowler*. Sablefish relative population weight in the Gulf of Alaska decreased 12% from 1996 to 1997, following a 18% increase from 1995 to 1996. Approximately 3,850 sablefish, 495 shortspine thornyhead, and 295 Greenland turbot were tagged

and released during the survey. Length-weight data and otoliths were collected from approximately 2,600 sablefish.

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

ABL Sablefish Tag Recovery Program

Processing tag recoveries and administration of the reward program continued during 1997. Data entry and production of tag reward letters were streamlined further by the development of Oracle forms and reports more suited to a UNIX environment. The database for sablefish tagged and released in Alaska waters now contains 288,910 release records and 20,192 recovery records. The number of recoveries per year (about 650 in 1997) continued to decline due to low numbers of tags released since the final Japan-U.S. cooperative longline survey in 1994. Over 38% of fish recovered in 1997 had been at liberty for more than 10 years, and five of those fish had been out for more than 24 years. Tagging was resumed in 1997, with 3,847 adult sablefish tagged and released during the annual AFSC longline survey.

Otoliths from seven known-age sablefish (i.e., fish tagged as juveniles) were recovered during 1997, bringing the total otolith collection of these fish to 81. A manuscript describing the initial findings of this study has been submitted to Fishery Bulletin.

Otoliths from three more oxytetracycline (OTC)-tagged fish were recovered during 1997; in all, otoliths have been collected from 68 of these fish. Some OTC-marked otoliths have been collected in each of the 9 years since the tagging was carried out. To date, most of these otoliths have not been examined.

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

Juvenile Sablefish Studies

Juvenile sablefish studies have been conducted by ABL in Alaska since 1984 and were continued in 1997. Approximately 50 juvenile sablefish (age 1+) were tagged and released during a cruise of the NOAA ship *John N. Cobb* at St. John Baptist Bay and Silver Bay, near Sitka, in May 1997. The small number of fish caught at St. John Baptist Bay was unusual, as large numbers have been consistently found at this locality each year since the bay was first sampled in 1985. In late summer, however, juvenile sablefish were found in inside waters of southeastern Alaska near Auke Bay for the first time since 1985, and large numbers of young-of-the-year (YOY) sablefish were reported by fishermen in offshore waters of this region. Large catches of YOY sablefish were also taken in surface rope-trawls during a juvenile salmon cruise of the *John N. Cobb* off Cape Spencer in October. A YOY sablefish study, which started in 1995, was conducted again in 1997 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. Detailed results from this study are unavailable at

this time, but a total of approximately 850 YOY sablefish were caught. Both the juvenile tagging and YOY sablefish studies are planned to be continued in 1998.

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

Sablefish Stock Assessment

Bering Sea, Aleutian Islands, and Gulf of Alaska

Determination of sablefish abundance in Alaska is largely based on results of the annual AFSC sablefish longline survey. The population is decreasing from a peak in the mid-1980s. The peak is attributed to strong recruitment in the late 1970s; recruitment has decreased in recent years. If recent recruitment levels continue, the population is projected to continue to decrease until 2000, stabilizing near the historic low. The decrease has been concentrated at the outer range of the distribution for sablefish in the Bering Sea and Aleutian Islands, while abundance in the Gulf of Alaska has not decreased as much.

Until 1997, yield estimates were determined from a stock reduction analysis modified to explicitly track estimates of exploitable biomass and provide an estimate of recruitment. The Bering Sea, Aleutian Islands, and Gulf of Alaska regions have been combined and analyzed as one stock since 1989. The recommended yield is then apportioned by management area according to estimates of current biomass using an exponential weighted average of past apportionment estimates. The ABCs for 1990-92 were computed by multiplying the $F_{0.1}$ exploitation rate (0.116) by the estimate of exploitable biomass at the beginning of the fishing year. For ABCs for 1993 through 1996, an adjustable fishing rate strategy was adopted for sablefish, whereby the $F_{35\%}$ fishing rate (that rate which would reduce the spawning biomass per recruit ratio to 35% of the unfished level) was adjusted in proportion to the ratio of current biomass to a target biomass level that is 35% of the unfished level ($B_{35\%}$). For the 1997 and 1998 ABC, new overfishing guidelines adopted by the NPFMC indicated that an adjusted $F_{40\%}$ strategy be considered for sablefish.

In 1997 and 1998, estimates of exploitable biomass and recruitment were determined from an age-structured model, which utilizes longline survey CPUE, survey age and length frequencies, and reported commercial catch in weight. Projected exploitable biomass for 1998 is 208,000 t. This estimate tries to account for possible under-reporting of commercial catches during 1986-90. Yield was 19,000 t using the adjusted $F_{40\%}$ fishing rate. If recent low levels of recruitment continue, these scenarios project that the population will decrease and the adjusted $F_{40\%}$ strategy will result in yield of 16,000 t when abundance is projected to stabilize in 2000.

The yield from an adjusted $F_{40\%}$ strategy represents a substantial increase over recent catches and ABCs. Increasing ABC is inconsistent with a population that is considered to be decreasing and below target levels. Rather than increasing 1998 ABC, and then reducing it rapidly in following years toward the predicted short-term equilibrium, it was recommended that current catch or ABC be incrementally adjusted toward the short-term equilibrium yield. Using 3-year increments, such an equilibrium adjusted value is 16,800 t, and was the recommended and

adopted 1998 ABC for the combined Alaska stock. The 1998 ABC was a decrease of 2.3% from the 1997 ABC of 17,200 t.

An exponential weighting of regional sablefish relative population weights in the longline survey is used to apportion the combined ABC to regions. Applying this weighting scheme results in a percent distribution of the total ABC of 84.06% for the Gulf of Alaska, 7.73% for the Bering Sea, and 8.20% for the Aleutian Islands. Thus, a total stock ABC of 16,800 t would be apportioned 14,123 t, 1,299 t, and 1,378 t for the Gulf of Alaska, Bering Sea, and Aleutian Islands, respectively.

A similar exponential weighting is used to apportion the 1998 TAC within the Gulf of Alaska. This results in 13.01%, 44.79%, 16.21%, and 25.99% for the Western, Central, West Yakutat, East Yakutat/Southeast areas, respectively. The apportionment of the 14,123 t Gulf of Alaska ABC results in 1,837 t in the Western Area, 6,325 t in the Central Area, 2,289 t in the West Yakutat Area, and 3,671 t in the East Yakutat/Southeast Area.

The high ABCs in the mid- to late 1980s were the result of a few large year classes which occurred in the late 70s and early 80s. The last large year class occurred in 1981, and at present, there is no indication of a comparable strong year class for at least another 4 years, at which time the population could be at historical low levels. The magnitude of the sablefish stock and the appropriate fishing rate largely depends on future recruitment, and little is known about the factors that determine recruitment levels.

For more information, contact Dr. Michael Sigler (907)789-6037, Dr. Jeff Fujioka (907)789-6026, or Sandra Lowe (206)526-4230.

Flatfish Stock Assessment

Bering Sea

Yellowfin sole

Two abundance estimators (trawl survey and stock synthesis) 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 15 years.

For the most part, 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 2,160,000 t, a 6% decrease relative to last year's estimate. The model projects the 1998 age 2+ biomass at 3,010,000 t.

In terms of model outputs, one change in the present assessment is that $B_{40\%}$ is estimated for the first time, with a value of 593,000 t. Last year, the SSC determined that reliable estimates of $F_{40\%}$ and $F_{30\%}$ existed for this stock and that yellowfin sole therefore qualified for management under tier 4 of Amendment 44. The 1998 ABC of 220,000 t and OFL of 314,000 t are calculated

using tier 3a since the estimated 1998 spawning biomass of 757,000 t exceeds $B_{40\%}$. The 1997 catch of 181,400 t is the highest observed in the past 10 years. Reliable estimates of F_{MSY} or B_{MSY} are not available for this stock.

Rock sole

An age-based synthesis model was used to assess the rock sole stock. The time series of abundances estimated by the model generally parallels that from the trawl survey quite closely, apart from the 1994 survey value and the 1997 estimate, which appear to be overestimates. Both the model and the survey indicate a dramatic increase in rock sole abundance throughout the 1980s and early 1990s.

For the most part, 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 2,710,000 t, a 24% increase relative to last year's estimate. This year's Aleutian bottom trawl survey resulted in a biomass estimate of 56,200 t, a 31% increase relative to the 1994 estimate. The model projected the 1998 age 2+ biomass at 2,360,000 t. In terms of model outputs, one change in the present assessment is that $B_{40\%}$ is estimated for the first time, with a value of 267,000 t. Last year, the SSC determined that reliable estimates of $F_{40\%}$ and $F_{30\%}$ existed for this stock and that rock sole therefore qualified for management under tier 4 of Amendment 44. The 1998 ABC and OFL recommendations were calculated under tier 3 rather than tier 4 since the estimated 1998 spawning biomass of 650,000 t exceeds $B_{40\%}$, thereby placing rock sole in sub-tier "a" of tier 3. The Plan Team recommended setting F_{ABC} at the $F_{40\%}$ (=0.16) level, which is the maximum allowable under tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 1998 ABC of 312,000 t. The OFL was determined from the tier 3a formula, where an $F_{30\%}$ value of 0.23 gives a 1998 OFL of 449,000 t.

The model indicates that biomass has remained high and stable during the mid-1990s. The 1987 year class continues to appear exceptionally strong, and the 1990 year class appears to be above average as well.

Flathead sole

This year's EBS bottom trawl survey resulted in a biomass estimate of 808,000 t, a 31% increase relative to last year's estimate. The 1997 Aleutian bottom trawl survey resulted in a biomass estimate of 16,200 t, a 5% increase relative to the 1994 estimate. The present assessment includes several changes from last year's assessment, incorporating new catch and survey information as well as presenting a preliminary length-structured model for initial review. As in past years, the combined Bering Sea and Aleutian Islands bottom trawl survey estimates are used to estimate the stock size, estimated at 824,000 t for the age 3+ biomass. Last year, the SSC determined that reliable estimates of $F_{40\%}$ and $F_{30\%}$ existed for this stock and that flathead sole therefore qualified for management under tier 4 of Amendment 44. Although an estimate of $B_{40\%}$ is presented in the appendix to the flathead sole chapter, this estimate is considered preliminary by the chapter authors and was not available for Plan Team review. The Plan Team recommended setting F_{ABC} at the $F_{40\%}$ (=0.16) level, which is the maximum allowable under tier 4. Projected

harvesting at the $F_{40\%}$ level gives a 1998 ABC of 132,000 t (compared to 101,000 t in 1997). The Plan Team's OFL was determined from the tier 4 formula, where an $F_{30\%}$ value of 0.23 gives a 1998 OFL of 190,000 t.

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). This year's EBS bottom trawl survey resulted in biomass estimates of 643,000 t for Alaska plaice and 70,300 t for the remaining members of the "other flatfish" complex, representing respective increases of 22% and 17% relative to last year's estimates. This year's Aleutian bottom trawl survey resulted in a biomass estimate of 9,500 t, a 42% increase relative to the 1994 estimate. In the present assessment, an age-based synthesis model was used for Alaska plaice. The synthesis model indicates that Alaska plaice recruitment was above average for all year classes spawned between 1969 and 1981, and below average for all but two year classes spawned since 1981 which has resulted in a decline biomass. In the present assessment (Alaska plaice only), $B_{40\%}$ is estimated for the first time at a value of 112,000 t. Last year, the SSC determined that reliable estimates of $F_{40\%}$ and $F_{30\%}$ existed for this stock complex and that "other flatfish" therefore qualified for management under tier 4 of Amendment 44. Since the estimated 1998 spawning biomass of Alaska plaice (233,000 t) exceeds $B_{40\%}$, "other flatfish" management uses sub-tier "a" of tier 3. The Plan Team recommended setting F_{ABC} at the $F_{40\%}$ level (0.29 for Alaska plaice, 0.16 for the remaining members of the complex), which is the maximum allowable under tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 1998 ABC of 164,000 t. The Plan Team's OFL was determined from the tier 3a formula, where an $F_{30\%}$ value (0.45 for Alaska plaice, 0.23 for the remaining members of the complex) gives a 1998 OFL of 253,000 t.

Greenland turbot

The length-based synthesis model used last year was updated for the present assessment. The protracted period of poor recruitment observed for this stock over the past several years continues. The present assessment includes several changes from last year's assessment, incorporating new catch and survey information as well as changes in other model inputs and model structure. This year's EBS bottom trawl survey resulted in a biomass estimate of 29,200 t, a 4% decrease relative to last year's estimate. This year's Aleutian bottom trawl survey resulted in a biomass estimate of 32,000 t, a 10% increase relative to the 1994 estimate. Two changes in the assessment models themselves were the use of a corrected weight-length relationship and the elimination of alternative model configurations corresponding to different projected catch distributions by gear type. The only catch distribution considered in the present assessment is a 50:50 split between trawl and longline gear. Last year, the SSC determined that reliable estimates of $B_{40\%}$, $F_{40\%}$, and $F_{30\%}$ existed for this stock, and that Greenland turbot therefore qualified for management under tier 3 of Amendment 44. The updated estimates of $B_{40\%}$ (measured in units of

spawning biomass), $F_{40\%}$, and $F_{30\%}$ from the present assessment are 138,000 t, 0.26, and 0.40, respectively. Projected spawning biomass for 1998 is 95,000 t, placing Greenland turbot in sub-tier "b" of tier 3. The F_{ABC} value was set at the maximum level allowed under tier 3b, which is computed as follows:

$$F_{ABC} \leq F_{40\%} \times (B_{98}/B_{40\%} - 0.05)/(1-0.05) = 0.27 \times (95{,}000/138{,}000-0.05)/0.95 = 0.17$$

A fishing mortality rate of 0.17 translates into a 1998 ABC of 15,000 t. The OFL fishing mortality rate is computed under tier 3b as follows:

$$F_{OFL} = F_{30\%} \times (B_{98}/B_{40\%} - 0.05)/(1-0.05) = 0.40 \times (95{,}000/138{,}000-0.05)/0.95 = 0.27$$

A fishing mortality rate of 0.27 translates into a 1998 OFL of 22,300 t.

Arrowtooth flounder

The length-based synthesis model used last year was updated for the present assessment. Good recruitment from the 1977 year class and several year classes spawned during the 1980s combined with minimal harvest has maintained arrowtooth flounder at a high level of abundance, although the stock is projected to decline in the near future. This year's EBS bottom trawl survey resulted in a biomass estimate of 479,000 t, a 14% decrease relative to last year's estimate. This year's Aleutian bottom trawl survey resulted in a biomass estimate of 94,100 t, a 31% increase relative to the 1994 estimate. In this years' assessment, $B_{40\%}$ is estimated for the first time, with a value of 43,600 t. Last year, the SSC determined that reliable estimates of $F_{40\%}$ and $F_{30\%}$ existed for this stock and that arrowtooth flounder therefore qualified for management under tier 4 of Amendment 44. Since the estimated 1998 spawning biomass of 531,000 t exceeds $B_{40\%}$, arrowtooth flounder is thereby placed in sub-tier "a" of tier 3. F_{ABC} is set equal to the $F_{40\%}$ (=0.23) level, which is the maximum allowable under tier 3a. Projected harvesting at the $F_{40\%}$ level gives a 1998 ABC of 147,000 t. The OFL was determined from the tier 3a formula, where an $F_{30\%}$ value of 0.36 gives a 1998 OFL of 230,000 t.

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

Gulf of Alaska

Management of the Gulf of Alaska flatfish resource has been divided into five categories by the North Pacific Fishery Management Council. These categories include: "shallow water flatfish", "deep water flatfish", arrowtooth flounder, flathead sole, and rex sole. This reclassification was made because of the significant difference in halibut bycatch rates in directed fisheries targeting on shallow and deep water flatfish species and also because of the dominant biomass of arrowtooth flounder which could cause the other flatfish species to be overfished if it was not separated from the group and managed under a separate TAC. Flathead sole are also

managed under a separate TAC because they overlap the distributions of the shallow and deep water categories and rex sole were given a separate TAC because of a problem with POP bycatch in the directed rex sole fishery in 1993. Arrowtooth flounder are now assessed separately.

Closures due to halibut bycatch in flatfish fisheries have kept catches well below their TAC, as in past years. In 1996 the shallow-water, deep-water, flathead sole and rex sole ABC apportionments were 18%, 15%, 11%, and 52% harvested. Biomass estimates from the 1996 Gulf of Alaska trawl survey indicate that the total flatfish resource remains stable with no significant changes estimated for any species between survey years. Trawl survey size compositions indicate the continued presence of juvenile fish recruiting to the stock for rock sole, flathead sole, and yellowfin sole. Recruitment patterns for rex and Dover sole are less clear.

The 1998 exploitable biomass is based on abundance estimated from a stock synthesis model and is estimated to be greater than $B_{40\%}$; therefore, arrowtooth flounder is in tier 3a of the overfishing definitions. The $F_{40\%}$ fishing mortality rate is 0.189 and was applied to the exploitable biomass estimate to determine an ABC estimate of 208,340 t for arrowtooth flounder.

The overfishing level is set at the catch resulting from the $F_{30\%}$ fishing mortality rate. For arrowtooth flounder $F_{30\%} = 0.27$ and the associated catch is estimated at 295,970 t.

For 1998, the flatfish species are managed with a combined ABC of 293,920 t and a TAC of 78,990 t.

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

Pacific Whiting Stock Assessment

This year represents the first jointly produced U.S. and Canada Pacific whiting assessment. The assessment was based on the stock synthesis model applied to data from the U.S. fishery, the Canadian fishery, NMFS acoustic surveys, NMFS triennial bottom trawl surveys, and Canadian Department of Fisheries and Oceans (DFO) acoustic surveys. Model results indicated that population biomass peaked in 1987 at 5.7 million t, then declined steadily to 1995. The biomass of age 3 and older fish was estimated to have increased slightly to 1.661 million t in 1996. Population projections for 1996-98 indicate that population biomass will range between 1.5 and 1.9 million t during this period. Likelihood profiles over acoustic survey catchability indicated that there was insufficient information to establish the absolute level of abundance when the assumption that survey catchability equals 1.0 was relaxed.

To forecast harvests for 1998-2000, a stochastic age-structured population model for Pacific whiting was used. Harvests projections are highly dependent of the estimated size of the 1994 year class, which in turn depends on the selectivity of the age-2 fish in the 1996 fishery. The assessment presents two sets of yield projections for 1998-2000 for different assumptions of age-2 selectivity in 1996. In the first set of projections, age-2 selectivity was assumed to be equal to age-3 selectivity in 1996 (0.19), producing an age-2 recruitment estimate of 2.423 billion fish. For this scenario, the hybrid F harvest strategy, used to manage the Pacific whiting resource since 1991, resulted in a 1998 yield of 208,000 t at a low harvest rate, 309,000 t at a moderate harvest rate, and 410,000 t at a high harvest rate. For the second set of projections, age-2 selectivity was

assumed equal to the age-4 selectivity in 1996 (0.53), resulting in an age-2 recruitment estimate of 0.918 billion fish. For this scenario, a 1998 yield of 116,000 t at a low harvest rate, 174,000 t at a moderate harvest rate, and 233,000 t at a high harvest rate was projected. These harvest rates are based on the probability that female spawning biomass will drop below a cautionary level of 420,000 t in long-term simulations of the Pacific whiting population (0.1 for the low harvest rate, 0.2 for the moderate harvest, and 0.3 for the high harvest rate). Yields in 1999 and 2000 show a wide range depending on the sequence of recruitments that occur in 1998-2000. Yields are most likely to decline significantly in 1999 and 2000.

The transboundary STAR Panel 1) concurred with the Pacific whiting STAT Team's choice to emphasize the recent acoustic survey and fishery catch data while lowering the emphasis of the NMFS bottom trawl and DFO acoustic surveys; 2) was comfortable with the use of a single coastwide model compared to previous versions of the model which had a U.S. and Canadian fishery with a migration pattern; 3) emphasized the importance of the NMFS acoustic survey and endorsed the use of the new target strength of 20 log (length) -68 dB; 4) recognized that uncertainty in q translates directly into uncertainty in the current spawning biomass, but endorsed the STAT Team decision to assume q=1; and 5) recognized that uncertainty in the estimate of 1994 year-class strength is the major source of the deviation between the results of the two models presented, and that consequently the yield projections have a large range as well.

The STAR Panel suggested the GMT utilize the STAT Team's decision table as the basis for its ABC and harvest guideline recommendations. The GMT reviewed the decision table and initially considered recommending the 1998 Pacific whiting ABC be set as a range of 174,000 t to 309,000 t. Further ABC and harvest guideline considerations were 1) if the 1994 year-class recruitment is the higher 2.423 billion age-two recruits and management action supported that assumption the 1998 yield of 309,000 t would result in a 20% utilization. From 1972 to 1991 the total utilization never exceeded 9.7% and during 1992 to 1996 the mean utilization was 13.7% with a high of 18.1% during 1996; and 2) if the 1994 year-class recruitment is the lower 0.918 billion age-2 recruits and management action supported higher recruitment assumption the 1998 yield of 309,000 t would result in a 27% utilization. In light of these considerations, the GMT's 1998 whiting ABC recommendation was the status quo level of 290,000 t, and status quo preliminary U.S. harvest guideline of 232,000 t.

For further information, contact Martin Dorn (206)526-6548.

Walleye Pollock Research

Acoustic Surveys - MACE Task

Bering Sea

Bottom trawl and echo integration-trawl surveys together provide biomass estimates of demersal and pelagic pollock on the eastern Bering Sea shelf. Bottom trawl surveys are conducted annually and assess pollock from the bottom to 3 m off bottom. Echo integration-

trawl surveys have been conducted triennially since 1979 to estimate pollock in midwater. A survey was also conducted in 1996 (outside the triennial series) to address concerns about recruitment.

The most recent echo integration-trawl survey was carried out 16 July to 6 September, 1997 westward from Port Moller, Alaska to the U.S./Russia Convention Line. The trackline consisted of north-south transects spaced 20 nmi apart and was designed to coincide with lines of groundfish trawl stations sampled by bottom trawl survey vessels. Pollock were distributed throughout the survey area with the highest densities encountered in the regions west and south of St. Matthew Island and between Unimak Island and St. George Island. Biomass of pollock in midwater (from near the surface to 3 m from the bottom) was estimated at 2.6 million t with 0.8 million t east of 170°W long. and 1.8 million tons west of 170°W long. Pollock ranged in length from 10 to 73 cm with a major mode at 16 cm and minor modes at 27 and 40 cm. East of 170°W long., pollock numbers were dominated by the 1996 year class (age 1). West of 170°W long., the 1996 year class was again the most numerous, followed by the 1995 (age 2) and 1992 (age 5) year classes. The 1996 year class totaled 12.4 billion fish for the survey area. In terms of biomass, the 1992 year class accounted for 0.9 million t and the 1996 and 1995 juvenile year classes made up 0.4 million t each.

MACE Program scientists also conducted an echo integration-trawl survey of the southeastern Aleutian Basin near Bogoslof Island on 1-10 March 1998. Scientists from Korea and Japan also participated in the survey. The work was conducted aboard the NOAA ship *Miller Freeman.* The target species was walleye pollock. This was the tenth annual survey (excepting 1990) in a series that began in 1988 with the objective of assessing the population distribution and abundance of spawning pollock in this region. The survey area encompassed a region extending from approximately 166° 00'W long. to 170° 20'W long. and 20-80 nmi offshore. Acoustic data were collected along a trackline consisting of 27 transects spaced at 10 nmi in the region east of 167° 10'W long. and 5 nmi west of that point. Fourteen midwater trawl hauls were made to sample echosign and provide biological data on the spawning pollock. The geographic distribution of pollock was similar to that observed in 1996 and 1997. Approximately 70% of the biomass was located in the off-shelf waters between the Islands of Four Mountains and the west end of Umnak Island. The majority of the fish encountered were in pre-spawning condition. Lengths ranged from 34 to 66 cm with a major mode at 54 cm, and fish < 48 cm comprised 17% of the population. Preliminary analyses resulted in a biomass estimate of 0.5 million tons.

Gulf of Alaska

An EIT survey to assess the distribution and abundance of spawning walleye pollock within the Shelikof Strait area was conducted between Chirikof Island and Cape Chiniak during 11-25 March 1998. This is the seventeenth annual spawning stock survey of walleye pollock in the Shelikof Strait area since 1980 (no survey in 1982). A total of 1,800 nmi of transect trackline and 31 hauls were completed during the survey. As in previous years, most spawning pollock were distributed along the western side of the Strait with greatest densities near Capes Kekurnoi and Kuliak. Fish were most abundant within 50-150 m of the bottom. The size distributions of pollock from hauls within the strait generally exhibited dominant modes around either 30-39 cm

or 50-60 cm fork length (FL). Sixty percent of the females greater than 34 cm FL were either pre-spawning or spawning and only 9% were spent. Pollock from the 1994 year class (ca. 30-39 cm FL mode) formed a strong, well-defined midwater layer (150-200 m depth) which was broadly distributed from about Uyak Bay south to Sitkinak Strait. The areal extent and strength of this layer of 4-year old fish supports earlier EIT survey observations that the 1994 year class is relatively strong.

For more information, contact Neal Williamson (206)526-6417.

Recruitment Processes (FOCI)

Fisheries-Oceanography Coordinated Investigations (FOCI), a NOAA cooperative research program between the Recruitment Processes Task of the RACE Division and the Pacific Marine Environmental Laboratory (PMEL) is designed to investigate the causes of recruitment variations in commercially important fish and shellfish. The program's focus is the well-defined spawning population of walleye pollock in Shelikof Strait, and walleye pollock stock structure and recruitment in the eastern Bering Sea. FOCI research in the Bering Sea is part of the NOAA Coastal Ocean Program. Areas of research include field studies of eggs and larvae in relation to primary and secondary production and the physical environment, biochemical methods for assessing larval starvation and predation and stock structure, and pollock behavior. FOCI participated in eight cruises aboard the NOAA ship *Miller Freeman* and two aboard the Oregon State University ship *Wecoma* during 1997, one in the Shelikof Strait region of the Gulf of Alaska, and seven in the Eastern Bering Sea to study the effects of the environment on the eggs and larvae of walleye pollock. We also conducted a study of young-of-the-year juvenile pollock in the Bering Sea near the Pribilof Islands in late summer, and participated in a cruise aboard the Japanese fisheries research ship *Oshoro Maru* in the Eastern Bering Sea during the summer. Laboratory studies on reared pollock larvae were conducted to calibrate biochemical indices, and estimate feeding, respiration, digestion, and gastric evacuation rates. Eggs were spawned from fish trawled in the Shelikof Strait and Bogoslof Island area, maintained in refrigerators aboard ship, and then transported in thermos jugs to the culture center at Sand Point in Seattle.

For more information, contact Dr. Art Kendall (206)526-4108.

Walleye Pollock Stock Assessment

Bering Sea and Aleutian Islands

This year's pollock assessment features a large amount of new data, including the results of recent bottom trawl and echo integration trawl (EIT) surveys, and several assessment models. The 1997 bottom trawl survey estimated a biomass of 3,860,000 t, an increase of 21% relative to the 1996 estimate, while the 1997 EIT survey estimated a biomass of 2,570,000 t, an increase of 11% relative to the 1996 estimate. Among the models presented in the assessment are the two

traditional cohort analyses that have served as the backbone of the pollock assessment for many years, plus six varieties of a Statistical Age-structured Model (SAM), similar to the Bayesian alternative model described in the appendix to last year's chapter. Because models such as the six SAMs provide a more rigorous and explicit treatment of uncertainty in the data, the Plan Team recommended that a model of this type be adopted as the main analytic tool for assessment of EBS pollock. Of the six varieties of SAM presented, the pollock assessment focused mostly on SAM #1 and SAM #4, the difference being that SAM #1 assumes a Ricker stock-recruitment relationship while the SAM #4 assumes that recruitment is independent of stock size.

The assessment presents an ABC range for 1998 extending from 1,110,000 t to 1,300,000 t, the endpoints of which correspond to outputs from SAM #4 and SAM #1, respectively. More specifically, for each of these two models a candidate ABC was computed by multiplying the harmonic mean yield projected under an $F_{40\%}$ harvest strategy by the ratio of projected 1998 spawning biomass to $B_{40\%}$. Given that the fits to the data provided by SAM #1 and SAM #4 are virtually identical and that the chapter authors did not establish a preference between these two models, the Plan Team had some difficulty determining which model to choose for the purpose of recommending a 1998 ABC value. However, the Plan Team ultimately concluded that SAM #4 should be chosen, for the following reasons: 1) the EBS pollock stock is on a downward trend and is projected to continue downward for at least the next year, 2) the strength of the 1996 year class, which is presently estimated as being above average and which could be particularly important to any near-term change in the overall abundance trend, is still fairly uncertain owing to this cohort's brief tenure in the population, and 3) the 1998 ABC value from SAM #4 is very close to this year's ABC while the 1998 ABC value from SAM #1 is significantly higher. The recommended ABC of 1,110,000 t from SAM #4 would maintain a stable level of harvests through the coming year, during which time further model development and evaluation can take place. For comparison, the projected 1998 catch under an $F_{40\%}$ harvest strategy from the two traditional cohort analyses is 1,140,000 t (subjective tuning) and 1,080,000 t (least-squares tuning).

Last year, the SSC determined that reliable estimates of B_{MSY} and F_{MSY} exist for this stock, with values of 6,000,000 t and 0.38 respectively, and that EBS pollock therefore qualified for management under tier 2 of Amendment 44. The projected age 3+ biomass for 1998 estimated from SAM #4 (5,820,000 t) is less than B_{MSY} (6,000,000 t), thereby placing EBS pollock in sub-tier "b" of tier 2. Under tier 2b, the ABC fishing mortality rate is capped as follows:

$$F_{ABC} \leq F_{MSY} \times (B_{98}/B_{MSY} - 0.05)/(1-0.05) = 0.38 \times (5{,}820{,}000/6{,}000{,}000 - 0.05)/0.95 = 0.37.$$

It is important to note that the model used to derive the accepted F_{MSY} estimate of 0.38 assumed knife-edge selectivity whereas SAM #4 allows selectivity to vary with age, meaning that full-selection fishing mortality rates from SAM #4 are not comparable to fishing mortality rates used to set ABC and OFL for pollock in the past. Fortunately, the fishing mortality rates for SAM #4 presented by the chapter authors have been calculated in such a way as to be roughly comparable to the knife-edge rates used in the past. For $F_{40\%}$, the full-selection value is 0.65, whereas the value reported in the assessment is 0.36. The fishing mortality rate corresponding to the recommended 1998 ABC of 1,110,000 t is not reported in the pollock assessment, but may be

approximated by multiplying $F_{40\%}$ by the ratio of projected 1998 spawning biomass to $B_{40\%}$. For the full-selection value of 0.65, the resulting F_{ABC} is 0.54, while for the value of 0.36 reported in the assessment, the resulting F_{ABC} is 0.30. The latter value (0.30) is the relevant one to compare with the F_{ABC} cap (0.37) computed above, with which it is clearly consistent.

For $F_{30\%}$, the full-selection value (not given in the assessment) is 1.2, and the value reported in the assessment is 0.65. Under tier 2b, the OFL fishing mortality rate is set as follows (using the assessment-reported rates rather than the full-selection rates, to maintain comparability with the accepted estimate of F_{MSY}):

$F_{OFL} = F_{MSY} \times (F_{30\%} / F_{40\%}) \times (B_{98} / B_{MSY} - 0.05)/(1-0.05) = 0.38 \times (0.65/0.36) \times (5{,}820{,}000/6{,}000{,}000 - 0.05)/0.95 = 0.66.$

Unfortunately, the pollock assessment does not contain a harvest projection corresponding to the above F_{OFL} value. However, the F_{OFL} value of 0.66 is coincidentally very close to the reported $F_{30\%}$ value of 0.65, for which a 1998 harvest projection of 2,060,000 t is given.

Aleutian Islands:

This year's 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 age-structured model that was initially developed for last year's assessment is explored further in the present assessment. Unfortunately, this exploration led the assessment authors to conclude that immigration of pollock into the Aleutian Islands region from adjacent areas rendered the model unreliable for use in recommending ABC.

Last year, the SSC determined that reliable estimates of $F_{40\%}$ and $F_{30\%}$ existed for this stock and that Aleutian pollock therefore qualified for management under tier 4 of Amendment 44. Based on the disappointing behavior of this year's model, however, the assessment authors concluded that a reliable estimate of $F_{40\%}$ no longer exists for this stock. Anticipating that the SSC will also concur, the Plan Team based its ABC and OFL recommendations on the assumption that Aleutian pollock would qualify for management under tier 5 rather than tier 4. The recommended 1998 ABC is 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 OFL is 31,700 t, computed as the product of the 1997 survey biomass estimate and the natural mortality rate.

Bogoslof:

The 1997 hydroacoustic survey of the Bogoslof region resulted in a biomass estimate of 342,000 t for Area 518. 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 of Amendment 44. In the present assessment, the assessment authors support continued use of an $F_{40\%}$ value of 0.27. As in previous assessments, the Plan Team recommends estimating next year's Bogoslof biomass by using a natural mortality rate of 0.2 to decay the present year's survey biomass estimate. This procedure produces a projected 1998 biomass of 280,000 t. Given this estimate, an F_{ABC} value was set at the maximum level allowed under tier 3b, which is computed as follows:

$F_{ABC} \leq F_{40\%} \times (B_{98} / B_{40\%} - 0.05)/(1-0.05) = 0.27 \times (280{,}000/2{,}000{,}000-0.05)/0.95 = 0.026.$

A fishing mortality rate of 0.026 translates into an exploitation rate of 0.023 which, when multiplied by a projected biomass of 280,000 t, gives a 1998 ABC of 6,410 t. This ABC value notwithstanding, the Plan Team recommended that the existing prohibition against directed fishing on this stock be continued for the 1998 season. The Council set the TAC at 1,000 t to allow for the bycatch of some pollock in the Bogoslof area in pursuit of other species.

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

$F_{OFL} = F_{30\%} \times (B_{98} / B_{40\%} - 0.05)/(1-0.05) = 0.37 \times (280{,}000/2{,}000{,}000-0.05)/0.95 = 0.035.$

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

Gulf of Alaska

The projected 1998 exploitable biomass for pollock, estimated by the synthesis model, is 1,156,000 t, which is an increase of 51,000 t over 1997. This estimate represents age 3+ biomass and should only be compared with previous years' levels from the revised hindcast.

Relative to the 1997 SAFE, new sources of information include: a) age composition data from the 1996 bottom trawl survey; b) the 1997 Shelikof Strait hydroacoustic biomass estimate; c) length frequency data from the 1997 hydroacoustic survey; d) age composition data from the 1996 fisheries; e) updated estimates of discard and catch for 1996 and 1997; f) results of a sensitivity analysis exploring a reduction in the emphasis applied to age composition and length frequency data, and g)an alternative model constructed using C++ software and automatic differentiation library (AD model builder).

The 1997 Shelikof Strait biomass estimate was 570,100 t (compared to the estimate of 745,400 t from the 1996 survey). These values were adjusted in the stock assessment to be comparable to estimates from the old hydroacoustic system in order to provide a time series of a relative abundance index. The 1995 and 1996 surveys indicated a strong 1994 year class. The 1994 year class, which represented the largest estimates of 1 and 2 year-old fish in the history of the Shelikof Strait hydroacoustic surveys, continued as 3-year olds to dominate the total number of pollock estimated in 1997.

The biomass estimate for the area west of Cape St. Elias from the 1996 bottom trawl survey was 653,900 t, similar in magnitude to previous survey estimates. Length frequency distributions from the 1996 bottom trawl survey showed the strong 1994 year class in the Western and Central Gulf. In the eastern Gulf and the Shumagin region, a second smaller mode (assumed to be the 1995 year class) was observed. It was noted that the 1996 and 1997 hydroacoustic surveys found relatively low numbers of 1 year olds from the 1995 and 1996 year classes, respectively.

Length frequency information from the first trimester of the 1996 fishery showed evidence of the 1994 year class. The fishery catch-at-age data show the strong 1988, 1989, and 1994 year classes. The synthesis model configuration differed from last year in a) a reduction of the sample

size for age and length compositions (effective N) from 400 to year-specific estimates of N based on the number of hauls and deliveries that were sampled for pollock otoliths; b) the estimation of a single fishery selectivity vector for 1994-97; and c) the incorporation of age data from the 1994-96 hydroacoustic surveys, and the 1996 bottom trawl survey and commercial fishery. Rationale for the reduction in sample size included an improved overall fit to the model, and the assumption that the number of hauls sampled is a more appropriate indication of sample size than the total number of otoliths sampled.

Estimates of various fishing mortality rates based on biological reference points were determined from the stock synthesis model. The estimated $F_{30\%}$, $F_{35\%}$, and $F_{40\%}$ full-selection fishing mortality rates were 0.517, 0.426, and 0.355, respectively. The projected 1998 female spawner biomass of 258,000 t is below the $B_{40\%}$ female spawner biomass estimate of 267,600 t. Average historical recruitment from the 1964-65 year classes was used to calculate $B_{40\%}$.

Pollock are classified under tier 3b of the ABC/OFL guidelines, thus F_{ABC} cannot exceed the $F_{40\%}$ fishing mortality rate adjusted by the ratio of current spawner biomass to $B_{40\%}$. The $F_{ABC}(F_{40\%adjusted})$fishing mortality rate of 0.34 results in a yield of 120,800 t for the Western/Central Gulf, and is the recommended 1998 Western/Central ABC. The ABC is apportioned according to the biomass distribution of the exploitable population (>20 cm) in the 1996 bottom trawl survey: 25% in the Shumagin area (30,200 t), 42% in the Chirikof area (50,740) t), and 33% in the Kodiak area (39,860 t). Relative to the 1993 survey biomass distribution, the current biomass distribution increased in the Kodiak area and decreased in the Shumagin area, but was similar to the 1990 survey distribution.

The overfishing mortality rate (0.499) is $F_{30\%}$ adjusted by the ratio of the current spawner biomass to $B_{40\%}$, and corresponds to a harvest of 170,500 t for the Western and Central Gulf of Alaska. Therefore, pollock are not considered overfished at the ABC harvest level.

There is currently no new information to set an ABC for the eastern Gulf of Alaska. Future development of an age-structured analyses similar to that conducted for the western and central areas is planned. The ABC for the eastern Gulf is calculated as the ratio of the W/C ABC to 1996 survey exploitable biomass applied to the eastern Gulf exploitable biomass estimate. The eastern Gulf ABC is set at 11,000 t and the overfishing level is 15,600 t.

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

Other Related Studies

Seafloor Habitat Studies

Effects of Fishing on Seafloor Habitat

In 1996, ABL initiated studies to examine the effects of commercial fishing on seafloor habitat. A chartered manned submersible and chartered commercial trawl vessel were used to quantify changes to the seafloor caused by bottom trawling. Specific objectives were to document changes in epifauna and physical attributes of the seafloor caused by bottom trawling with tire gear. The experiment took place in the eastern Gulf of Alaska in rockfish habitat over hard bottom substrate during July and August 1996. In 1997, the 1996 submersible transects were repeated to document effects on seafloor habitat one year after trawling. In addition, the submersible was used in 1997 to observe trawl impacts on red tree coral, *Primnoa* sp. A trawl path was located at 365 m depth in Dixon Entrance where 2 t of red tree coral were caught during a 1990 trawl survey. The trawl path was identified by moved boulders and broken coral. Damage and abundance of coral in the trawl path will be compared to areas outside the trawl path.

Preliminary analysis of data collected in 1996 has been completed. The seafloor substrate at the experimental sites consisted of 92% pebble, 6% cobble, and 2% boulder. The trawl path could be identified by furrows in the substrate 1-8 cm deep caused by the tire gear attached to the trawl foot rope. A total of 30 species (or larger taxonomic groups) of invertebrates were identified. These species were categorized into sessile and motile groups. Densities of large erect sponges, morel sponges, and anthozoans were significantly lower in trawled sites compared to reference sites. Densities of the small finger sponges were not significantly affected by trawling. Extensive incidences of damage were detected for the three species of large erect sponges, and for sea whips, but not for morel sponges, finger sponges or anemones. No significant differences in density of motile groups were detected, though the densities of arthropods and molluscs tended to be greater in trawled sites, possibly because of a scavenging response to disturbance by the trawl. No significant damage due to trawling was detected for any of the motile groups, with the exception of brittle stars. Trawl bycatch, as a percentage of individuals present in reference transects, was calculated for spot prawns (46%), asteroids (<1%), echinoids (<1%), holothurians (5%), and molluscs (<1%).

For more information, contact Jonathan Heifetz (907)789-6054, Linc Freese (907)789-6045, or Ken Krieger (907)789-6053.

Trawling Impact Studies

Studies investigating potential impacts of bottom trawls on soft bottom benthos in the Bering Sea (TRAWLEX) were continued during 28 July to 15 August 1997 aboard the F/V *Golden Dawn*. As in 1996, operations were conducted in management area 512 in Bristol Bay because of the long history of trawl prohibitions there. This work addresses new mandates in the

Sustainable Fisheries Act of 1996 that require assessments of all activities with potential impact on essential fish habitat, specifically those related to fishing gear. Although similar scientific inquiries are being conducted in a number of other historically important areas around the world, local studies are necessary because responses to trawling will be very site-specific, reflecting the diversity of benthic systems and fishing gears and the relative importance of natural phenomena such as storms.

The research plan addressed both impact characterization and subsequent ecological recovery. Specifically: 1) Do bottom trawls have measurable effects on soft-bottom benthos in the eastern Bering Sea? 2) If impacts are identified, do affected areas revert to their original state, in the absence of fishing (if so, how quickly?) or are there fundamental changes which define a different recovery state? This project was a collaborative effort with the Western Marine and Coastal Surveys Team of the U.S. Geological Survey, Menlo Park, California. The USGS team contributed expertise in sidescan sonar, underwater video, benthic grab sampling, and dynamic gear tracking capabilities. Potential impacts were to be directly studied by comparing biological (NMFS) and geological (USGS) conditions before and after experimental fishing with a commercial bottom trawl. Previously untrawled areas in the eastern Bering Sea were identified by summarizing historical bottom trawl effort, using foreign regulations and catch statistics, international agreements, NMFS enforcement and surveillance reports, the NMFS observer databases (1973-96), as well as details of past and present regulatory closures. Field operations included coordinated sampling to describe epifauna and infauna populations and community structure, micropaleontology (diatoms, forams), descriptions of seafloor morphology and stratigraphy, and other ancillary studies. This experimental design required precise and real-time information on the position of the commercial trawl and scientific sampling gear because of the need to sample and resample experimental sites. Unfortunately, specialized equipment was unable to provide this information in the field, thus completion of the original experimental design was precluded and a substitute plan was implemented. Pre-trawling infauna sampling with a 0.1 m^2 Sutar van Veen device in the first experimental (n=15 grabs) and control (n=15 grabs) sites, as well as a sidescan survey of the experimental area, were completed prior to termination of this study.

Effects of chronic trawl exposure on infauna populations were investigated near the northeast corner of area 512. The historical summary of fishing effort (described above) identified pairs of 1 nmi^2 areas of the seafloor, consisting of adjoining unfished (inside) or heavily fished (outside) areas separated by the closed area boundary. These same sites were sampled during 1996 TRAWLEX studies investigating potential chronic effects of trawls on epifauna populations. A total of 60 (30 pairs) 0.1 m^2 Sutar van Veen grab samples were collected for the comparison. Various sidescan and video surveys spanning the experimental area and closed area boundary area were also performed. Infauna samples will be processed to the family level at the School of Fisheries and Ocean Sciences, University of Alaska Fairbanks (S. Jewett) and sidescan-video data sets are being processed by the USGS team.

For more information, contact Dr. Robert McConnaughey (206)526-4150.

Seabed Composition as it Relates to Survey Design

The RACE West Coast Groundfish team has been conducting a retrospective analysis of our triennial bottom trawl surveys conducted along the west coast from 1977 to 1995. While there are many different portions of this project, they are all related and hopefully the combined results will lead to a better understanding of how our survey samples the groundfish populations.

The first objective is to identify areas where we have been unable to successfully use our bottom trawl nets. This involves plotting the locations of poor performance hauls (trawl gear ripped or hung-up on bottom) and stations which were skipped because the bottom was too rough. Preliminary results show clustering of bad tows in some areas. For example, in the shallow stratum off northern Washington (U.S. Vancouver area, 55-183 m), approximately 42% of planned stations were not sampled successfully (1986-95). We are working with Washington State Department of Fish and Wildlife scientists to explore weather the abundance of some important commercial groundfish species are different in the untrawlable vs. trawlable areas. Species of particular interest in this study include lingcod and canary rockfish.

Along with delineating untrawlable areas, we plan to create a map of surficial sediments throughout our west coast survey area. This will be the first such map created using original data sources with sediments divided into constituent components (percent gravel, percent sand, percent silt, and percent clay). Previous maps have used data coded by a ternary diagram or only visually classified samples. To date, we have accumulated about 2,000 data points, with good coverage of the northern half of the survey area and weaker coverage of the southern half. We are working with the Geological Survey of Canada and the U.S. Geological Survey towards completing this goal. All data will be imported into a GIS package so that we can use spatial statistics to interpolate the data and produce a map which can be easily updated.

We also hope to conduct an assemblage analysis on the groundfish species, showing which species tend to occur together. Depth, bottom water temperature and sediment texture will be used to further define these assemblages. Age and length data from our catches, not normally included in assemblage analysis studies, may help us further refine these assemblages. Once completed, we hope to use that information to identify stations with similar catches, group the stations into strata, and then compare these strata to our current stratification system, based on depth and latitude. By minimizing differences in species composition between strata, more accurate estimates of species abundance with lower variance should be produced.

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

Effects of Trawling on Demersal Invertebrates

At the end of the standard Bering Sea Crab/Groundfish Survey an experiment was performed to estimate the effect of trawling on the bottom by sampling demersal invertebrate species in areas primarily closed to trawling and adjacent areas subject to intensive commercial trawling. Fifty-two pairs of tows were made in inner Bristol Bay around the perimeter of the red king crab Protection Zone 1. Analyses are continuing.

For more information, contact Gary Walters (206)516-4143.

Acoustic Bottom Typing

Acoustic bottom typing studies are also continuing in the Bering Sea and are designed to evaluate new technology as a potential source of habitat information for essential fish habitat characterizations. Currently, environmental descriptions of Bering Sea groundfish habitat are largely limited to spatial measures of water temperature and bathymetry, which themselves are closely correlated. Notably lacking are data related to more proximal habitat factors that affect abundance and distribution of demersal fish (and their benthic prey), such as physical attributes of the seafloor. In cooperation with the manufacturer of the *QTC View Seabed Classification System* (Quester Tangent Corporation, Sydney, B.C., Canada), we have been examining the feasibility of implementing the technology for use during routine hydroacoustic surveys performed by the MACE task aboard the NOAA ship *Miller Freeman*.

This year we successfully interfaced the *QTC View* system with the Simrad EK-500 scientific echosounder aboard the *Miller Freeman* and have begun evaluations of data quality and operational limits. During gear trials in Puget Sound during 7-9 July 1997, signal saturation problems were resolved, the effect of vessel speed on seabed classifications was examined, as was overall classification precision during repetitive runs over a preselected trackline. A initial classification catalog, covering substrates from mud to sand to shell to gravel and cobble, was also developed for use in the Bering Sea. Having successfully implemented the technology, direct evaluations of the *QTC View* system were conducted aboard the *Miller Freeman* during July-September 1997 (cruise MF 97-08). The equipment was operated in routine survey mode at two echosounder frequencies (38, 120 kHz), for the continuous classification of seafloor attributes and for refinement of the Bering Sea classification catalog. Grab samples were collected for calibration and validation purposes. Additional studies related to operational limits and the ability to discriminate similar mud-sand substrates were also conducted as part of a University of Washington M.S. thesis focused on the Gulf of Alaska. A higher end system from the same manufacturer (*ISAH-S*), continuously operated in the background, captured the digitized acoustic returns for evaluation of various hard-coded features of algorithms used by the *QTC View* system.

For more information, contact Dr. Robert McConnaughey (206)526-4150.

Hydroacoustic Survey Methodology

Acoustic Buoy Project

A free-drifting acoustic buoy was constructed in 1997 to evaluate the response of fish to vessel and trawl noise. The acoustic buoy consisted of a 1.30 m long aluminum cylinder with a "donut" floatation collar at one end. The buoy contains an echosounder and split beam transducer operating at 38 kHz, and other instrumentation to facilitate the remote operation of the device. An acoustic-buoy cruise was conducted over the eastern Bering Sea shelf during 29 September to 6 October 1998 to field test the buoy under a variety of sea conditions, and over walleye pollock echosign. Although no dense aggregations of pollock were located during the cruise, the buoy was successfully deployed four times under a variety of sea conditions (seas ≤8 ft; winds ≤26 kts). Performance of the buoy during the field trials was excellent

During the EIT survey of spawning walleye pollock within the Shelikof Strait area during March 1998 (see above), the buoy was deployed four times over walleye pollock. During the deployments, a total of 38 runs past the buoy were made by the NOAA ship *Miller Freeman* while free-running at 12 kts to determine whether the fish would respond to noise generated at vessel speeds used during routine EIT stock assessment surveys. The vessel additionally conducted two bottom trawl hauls near the buoy to investigate whether a response of walleye pollock would occur under these conditions. Preliminary results suggest that the fish did not exhibit dramatic responses to vessel noise generated during most runs of the vessel past the buoy. However, a more thorough examination of the data is in progress to verify these initial observations.

For more information, contact Dr. Chris Wilson (206)526-6435.

Trawl Survey Methodology

Survey Trawl Catchability Studies

Experiments conducted in 1997 that were related to the estimation of survey trawl efficiency include the auxiliary bag studies to estimate the net efficiency of the Poly Nor'eastern and 83-112 trawls and a study of the effect of lights on the escapement of fish under the footrope of the Poly Nor'eastern trawl. The net efficiency, or the proportion of fish entering the fishing path of the trawl which are captured, was estimated for the two survey trawls by attaching a bag under the belly of the trawl to capture fish escaping under the footrope. Efficiency generally increased with body size, but for some flatfish species efficiency reached a maximum at mid-sizes then subsequently declined. The variation in the pattern is believed to be due to species- and size-specific differences in behavior. Herding experiments to determine the proportion of fish between the trawl doors that are herded into the path of the net will be conducted in May of 1998. With the successful completion of these experiments, we will combine the results of both herding and net efficiency experiments to estimate the total efficiency of both trawls for cod and flatfish. The experiments to estimate herding and efficiency, however, can only be done on smooth bottoms which excludes many species such as ling cod, rockfish and Atka mackerel. As an alternative, we have examined the use of underwater video cameras, which could be used in any conditions usually sampled by the trawls, to estimate efficiency. One concern we have about this approach, the effect of lights on the behavior of fish, was addressed experimentally in 1997. The preliminary results of this experiment indicate that the light levels used in the video-based escapement studies produce no detectable effect on escapement.

For further information, contact Dr. David Somerton (206)526-4116, Peter Munro (206)526-4292, or Ken Weinberg (206)526-6109.

The Effect of Artificial Light on Footrope Capture Efficiency of a Survey Bottom Trawl

The groundfish task has conducted several gear research studies as part of an on-going effort to better understand the performance and efficiency of our standard survey bottom trawls. The most recent of these investigated the effect artificial light has on fish escapement beneath the Nor'eastern survey trawl and follows a 1995 flatfish escapement study wherein a self-contained video system equipped with a 50-watt halogen lamp was attached to the trawl to count the fish passing over and under the footrope. The advantage to estimating escapement using this method, rather than the more conventional but highly vulnerable capture bag positioned behind the footrope, is that the video system can accompany the trawl over a variety of rough bottom conditions inhabited by different fish assemblages. However, because most survey stations are at depths greater than natural light can penetrate for low-light camera use, artificial light must be added. One potential shortcoming of this technique is that the artificial light might alter fish behavior and thereby bias estimates of escapement. Our findings from the current experiment will have a direct impact on the usefulness of the video method for estimating escapement, as well as for other studies that rely upon artificial illumination and are concerned with the effect light may have on fish behavior.

The lights experiment was conducted in the Bering Sea aboard the F/V *Aldebaran* following the 1997 survey of crab and groundfish resources. Using a paired tow design (unlit and lit) at two depth sites offering varying levels of ambient light, we tested the hypothesis that the addition of artificial light directed at the footrope does not effect capture rates (captures / captures + escapes). We placed a separate auxiliary capture bag behind footrope of the Nor'eastern in order to capture the "escapes". We also attached the video system to the trawl according to our methods used in the previous flatfish escapement study so that the video camera was located just ahead of the footrope and the 50-watt lamp was directed back towards the center of the footrope and in the eyes of the fish attempting to outswim the trawl. Counts and length measurements of the fish taken in the main trawl were kept separate from those in the auxiliary capture bag. A total of 24 pairs of tows were made (14 deep and 10 shallow). While data analyses are still in progress, results thus far show strong empirical evidence suggesting that light did not alter rates of fish escapement among two flatfish and two gadid species.

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

Geographic Information Systems (GIS)

Virtually all studies utilizing GIS capabilities at the AFSC are being accomplished using ArcView. Bathymetric and coastline data sets have been developed from "best source" data sets by our resident ArcInfo specialist, Angie Greig of the REFM Division. Other data sets being used with ArcView are project specific and a number of coverages of haul locations, sediment classifications, and bottom type data.

For further information, contact Angie Greig (206)526-4236.

APPENDIX

Recent Publications and Reports Pertaining to Groundfish and Marine Habitats by Authors at the Alaska Fisheries Science Center

ANDERSON, P. J., J. E. BLACKBURN, and B. A. JOHNSON.
1997. Declines of forage species in the Gulf of Alaska, 1972-1995, as an indicator of regime shift, p. 531-543. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

BAILEY, K. M.
1997. Structural dynamics and ecology of flatfish populations. J. Sea Res. 37:269-280.

BAILEY, K. M., P.J. STABENO, and D. A. POWERS.
1997. The role of larval retention and transport features in mortality and potential gene flow of walleye pollock. J. Fish. Biol. 51 (Suppl. A):135-154.

BOVENG, P. L.
1996. Space and time relationships between vertebrate predators and a commercially harvested prey species in the Antarctic marine ecosystem, p. 83-89. *In*: 1996 Proceedings of the Biometrics Section of the American Statistical Association. American Statistical Association, Alexandria, Virginia

BRODEUR, R. D., M.T. WILSON, J .M NAPP, R. H. STABENO, and S. SALO.
1997. Distribution of juvenile pollock relative to frontal structure near the Pribilof Islands, Bering Sea, p. 573-589. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

BUCKLEY, T. W., and P. L. LIVINGSTON.
1997. Geographic variation in the diet of Pacific hake, with a note on cannibalism. Calif. Coop. Oceanic. Fish. Invest. Rep. 38:53-66.

BYRD, G. V., R. L. MERRICK, J. F. PIATT, and B. L. NORCROSS.
1997. Seabird, marine mammal, and oceanography coordinated investigations (SMMOCI) near Unimak Pass, Alaska, P. 337-350. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

CIANELLI, L., and R. BRODEUR.
1997. Bioenergetics estimation of juvenile pollock food consumption in the Gulf of Alaska (abstract), p. 71-75. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

CLAUSEN, D. M., J. T. FUJIOKA, and J. HEIFETZ.
1997. Estimates of sablefish, *Anoplopoma fimbria*, in the Gulf of Alaska based on depletion experiments using longlines, p. 171-182. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria.* U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

DORN, M. W.
1997. Mesoscale fishing patterns of factory trawlers in the Pacific hake (*Merluccius productus*) fishery. Calif. Coop. Oceanic. Fish. Invest. Rep. 38:77-89.

FUJIOKA, J. T., J. HEIFETZ, and M. F. SIGLER.
1997. Choosing a harvest strategy for sablefish, *Anoplopoma fimbria*, based on uncertain life-history parameters, p. 247-251. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria.* U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

HEIFETZ J., J. T. FUJIOKA, and T. J. QUINN, II.
1997. Geographic apportionment of sablefish, *Anoplopoma fimbria*, harvest in the northeastern Pacific Ocean, p. 229-237. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria.* U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

INCZE, L. S., D. W. SIEFERT, and J. M. NAPP.
1997. Mesozooplankton of Shelikof Strait, Alaska: Abundance and community composition. Cont. Shelf Res. 17(3): 287-305.

JOHNSON, S. W., M. G. CARLS, R.P. STONE, C. C. BRODERSEN,
and S. D. RICE.
1997. Reproductive success of Pacific herring, *Clupea pallasi*, in Prince William Sound, Alaska, six years after the *Exxon Valdez* oil spill. Fish. Bull., U.S. 95:748-761.

JOHNSTON, R.S., L. E. QUEIROLO, and A. EMAMI.
1997. Beyond EEZ: Re-thinking global fishery and trade policy. EEZ Technology, vol. 1: 41-45.

KIMURA, D. K., and H. H. ZENGER, JR.
1997. Standardizing sablefish (*Anoplopoma fimbria*) long-line survey abundance indices by modeling the log-ratio of paired comparative fishing CPUEs. ICES J. Mar. Sci. 54:48-59.

KRIEGER, K. J.
1997. Sablefish, *Anoplopoma fimbria*, observed from a manned submersible, p. 39-43. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria.* U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

KRIEGER, K. J., and M. F. SIGLER.
1996. Catchability coefficient for rockfish estimated from trawl and submersible surveys. Fish. Bull., U.S. 94: 282-288.

LENARZ, W.H., and F. R. SHAW.
1997. Estimates of tag loss from double-tagged sablefish, *Anoplopoma fimbria.* Fish. Bull, U.S. 95:293-299

LOWE, S. A., and J. T. FUJIOKA.
1997. Methods used in the determination of acceptable biological catch for sablefish, *Anoplopoma fimbria*, p. 159-169. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria.* U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

MALONEY, N. E., and J. HEIFETZ.
1997. Movements of tagged sablefish, *Anoplopoma fimbria*, in the eastern Gulf of Alaska, p. 115-121. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria.* U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

MCDERMOTT, S. F., and S. A. LOWE.
1997. The reproductive cycle and sexual maturity of Atka mackerel, *Pleurogrammus monopterygius*, in Alaska waters. Fish. Bull., U.S. 95:321-333.

NICHOL, D. G.
1997. Effects of geography and bathymetry on growth and maturity of yellowfin sole, *Pleuronectes asper*, in the eastern Bering Sea. Fish. Bull., U.S. 95:494-503.

PAYNE, S. A., B. A. JOHNSON, and R. S. OTTO.
1997. Proximate composition of some northeastern Pacific forage species (abstract), p. 721-724. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

QUEIROLO, L. E., Z. ZHANG, and R. S. JOHNSTON.
1997. The nature and evolution of cooperative fishing arrangements in extended jurisdiction zones. Marine Policy 21(2): 255-266.

RUTECKI, T. L., and E. R. VAROSI.
1997. Distribution, age, and growth of juvenile sablefish, *Anoplopoma fimbria*, in the Gulf of Alaska, p. 55-63. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

RUTECKI, T. L., and E. R. VAROSI.
1997. Migrations of juvenile sablefish, *Anoplopoma fimbria*, in Southeast Alaska, p. 123-130. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

SHAW, F. R., and N. B. PARKS.
1997. Movement patterns of tagged sablefish, *Anoplopoma fimbria*, recovered on seamounts in the northeast Pacific Ocean and Gulf of Alaska, p. 151-158. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

SIGLER, M. F., S. A. LOWE, and C. R. KASTELLE.
1997. Area and depth differences in the age-length relationship of sablefish, *Anoplopoma fimbria*, in Southeast Alaska, p. 45-54. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

STONE, R. P., and S. W. JOHNSON.
1997. Survival, growth, and bioaccumulation of heavy metals by juvenile Tanner crabs (*Chionoecetes bairdi*) held on weathered mine tailings. Bull. Environ. Contam. Toxicol. 58:830–837.

THEDINGA, J. F., A. MOLES, and J. T. FUJIOKA.
1997. Mark retention and growth of jet-injected juvenile marine fish. Fish. Bull., U.S. 95:629-633.

WILKINS, M. E., and M. W. SAUNDERS (editors).
1997. Biology and Management of Sablefish, *Anoplopoma fimbria*.. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130, 275 p.

WILKINS, M. E., and M. W. SAUNDERS.
1997. Introduction, p. 1. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*, p. 151-158. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

WILSON, M.
1997. Walleye pollock (*Theragra chalcogramma*) in the western Gulf of Alaska: The importance of nursery areas (abstract), p. 435-440. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

WING, B. L.
1997. Distribution of sablefish, *Anoplopoma fimbria*, larvae in the eastern Gulf of Alaska: Neuston-net tows versus oblique tows, p. 13-25. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

YANG, M.-S.
1997. Trophic role of Atka mackerel (*Pleurogrammus monopterygius*) in the Aleutian Islands (abstract), p. 277-279. *In* Proceedings of the International Symposium on the Role of Forage Fishes in Marine Ecosystems. Alaska Sea Grant College Program Report No. 98-01, University of Alaska Fairbanks.

ZENGER, H. H., JR.
1997. Comparisons of sablefish, *Anoplopoma fimbria*, abundance indices estimated from two longline surveys, p. 215-228. *In* M. E. Wilkins and M. W. Saunders (editors), Biology and management of sablefish, *Anoplopoma fimbria*. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-130.

ZIMMERMANN, M.
1997. Maturity and fecundity of arrowtooth flounder, *Atheresthes stomias*, from the Gulf of Alaska. Fish. Bull., U.S. 95:598-611.

1997 TECHNICAL MEMORANDUMS

EBBERTS, B. D. and B. L. WING.
1997. Diversity and abundance of neustonic zooplankton in the North Pacific Subarctic Frontal Zone. NOAA Tech. Memo. NMFS-AFSC-70, 34 p.

KINOSHITA, R. K., A. GREIG, D. COLPO, and J. M. TERRY.
1997. Economic status of the groundfish fisheries off Alaska, 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-72, 91 p.

LAUTH, R. R., M. E. WILKINS, and P. A. RAYMORE, JR.
1997. Results of trawl surveys of groundfish resources of the West Coast upper continental slope from 1989 to 1993. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-79, 342 p.

LAUTH, R. R.
1997. The 1995 Pacific West Coast upper continental slope trawl survey of groundfish resources off southern Oregon and northern California: Estimates of distribution, abundance, and length composition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-80, 110 p.

LAUTH, R. R.
1997. The 1996 Pacific West Coast upper continental slope trawl survey of groundfish resources off Washington and Oregon: Estimates of distribution, abundance, and length composition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-81, 156 p.

MARTIN, M. H.
1997. Data report: 1996 Gulf of Alaska bottom trawl survey. U. S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-82, 235 p.

RUTECKI, T.L., M. F. SIGLER, and H. H. ZENGER JR.
1997. Data report: National Marine Fisheries Service longline surveys, 1991-96. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-83, 64 p.

WILSON, C. D., and M. A. GUTTORMSEN.
1997. Echo integration-trawl survey of Pacific whiting, *Merluccius productus*, off the west coasts of the United States and Canada during July-September 1995. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-74, 70 p.

WING, B. L., C. W. DERRAH, and V. M. O'CONNELL.
1997. Ichthyoplankton in the eastern Gulf of Alaska, May 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-75, 42 p.

1997 AFSC PROCESSED REPORTS

DORN, M., S. GAICHAS, S. FITZGERALD, and S. BIBB.
1997. Evaluation of haul weight estimation procedures used by at-sea observers in pollock fisheries off Alaska. AFSC Processed Rep. 97-07, 76 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115-0070.

HEIFETZ, J. (editor).
1997. Workshop on the potential effects of fishing gear on benthic habitat. AFSC Processed Rep. 97-04, 17 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801-8626.

HILL, P. S., and D. P. DEMASTER.
1997. Marine Mammal Protection Act and Endangered Species Act Implementation Program 1996. AFSC Processed Report 99-10, 255 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115-0070.

MURPHY, J. M., and B. D. EBBERTS.
1997. Physical oceanographic observations in the central subarctic North Pacific Ocean, July-September 1991. AFSC Processed Rep. 97-06, 267 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Auke Bay Laboratory, 11305 Glacier Highway, Juneau, AK 99801-8626.

OTTO, R. S., J. A. HAAGA, and R. A. MACINTOSH.
1997. Report to industry on the 1996 eastern Bering Sea crab survey. AFSC Processed Rep. 97-02, 52 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

WALTERS, G. E.
1997. Report to the fishing industry on the results of the 1996 eastern Bering Sea groundfish survey. AFSC Processed Rep. 97-01, 58 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

WALTERS, G. E.
1997. Report to the fishing industry on the results of the 1997 eastern Bering Sea groundfish survey. AFSC Processed Rep. 97-08, 57 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115-0070.

WALTERS, G. E. (compiler).
1997. 1993 bottom trawl survey of the eastern Bering Sea continental shelf. AFSC Processed Rep. 98-09, 159 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115-0070.

WILKINS, M., T. WILDERBUER, and D. CLAUSEN (compilers).
1997. A review of groundfish research, assessments, and management conducted at the Alaska Fisheries Science Center during 1995. A report to the 1996 annual meeting of the Technical Subcomittee, Canada-U.S. Groundfish Committee. AFSC Processed Rep. 97-03, 41 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE., Seattle, WA 98115-0070.

IN PRESS

LIVINGSTON, P.A. and R.D. METHOT.
In press. Incorporation of predation into a population assessment model of eastern Bering Sea walleye pollock. p. 000-000. *In*: Proceedings of the Int. Symp. on Fishery Stock Assessment Models for the 21st Century. Alaska Sea Grant Publication.

LIVINGSTON, P.A., L-L. LOW, and R.J. MARASCO.
In press. Eastern Bering Sea ecosystem trends. p. 000-000. *In*: Large Marine Ecosystems of the Pacific Ocean: Assessment, Sustainability, and Management. Blackwell Science, Eds. Tang, Q., and K. Sherman. Blackwell Press.