REVIEW OF GROUNDFOX RESEARCH, ASSESSMENTS, AND MANAGEMENT
BY THE
ALASKA FISHERIES SCIENCE CENTER

Compiled By
Mark Wilkins, Tom Wilderbuer, and David Clausen

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VII. REVIEW OF AGENCY GROUNDFISH RESEARCH, ASSESSMENTS, AND MANAGEMENT

A. Agency Overview

Essentially all groundfish research at the Alaska Fisheries Science Center (AFSC) is conducted within the Resource Assessment and Conservation Engineering (RACE) Division, the Resource Ecology and Fisheries Management (REFM) Division, and the Auke Bay Laboratory (ABL), which is responsible for groundfish assessment in the Gulf of Alaska east of Cape St. Elias. The RACE and REFM Divisions are divided along regional or disciplinary lines into a number of tasks and subtasks. A review of pertinent work by these tasks during the past year is presented below. Recent publications (incomplete list) produced by RACE, REFM, and ABL scientists are presented as Appendix I. An updated list of publications will be made available at a later date.

RACE DIVISION

In 1991 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. Dr. David Somerton was hired in October 1991 to lead the RACE Groundfish Assessment Task. Dr. Richard Bakkala retired in December 1991 and Gary Walters was recently promoted to replace him as Subtask Leader of the Bering Sea Groundfish Subtask. Groundfish surveys were conducted by the Bering Sea, Gulf of Alaska, and West Coast subtasks. There were five bottom trawl surveys, two longline surveys, and one trap survey conducted in 1991. Major emphasis was in the Bering Sea and Aleutian Islands, in keeping with the rotation of comprehensive surveys among three major geographic areas on a triennial basis. The focus will be off the West Coast in 1992. The Pelagic Resource Assessment Task conducted two surveys of pollock abundance in the Gulf of Alaska and Bering Sea. A recent reorganization places the old Conservation Engineering (gear/fish interactions and behavior research) under the Pelagic Resource Assessment Task to capitalize on developments in technology. The Recruitment Processes task conducted four Fisheries-Oceanography Coordinated Investigations (FOCI) cruises in the spring of 1991, investigating the interaction between the environment and the spawning products of Gulf of Alaska pollock.
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 Foreign Fisheries Observer Program and the following tasks: Age and Growth Studies, Socioeconomic Assessments, Resource Ecology and Ecosystems Modeling, and Status of Stocks and Multispecies Assessments. The work of these tasks culminates as technical reports and advice to the appropriate fishery management councils and international fisheries commissions. Some changes were made in significant positions within the Division since last year. Dr. Jim Balsiger left the Status of Stocks Task to become the AFSC Deputy Director. He was replaced by Dr. Richard Methot as Task leader and Drs. Anne Hollowed and Vidar Wespestad were promoted to Sub-Task Leaders for the North Pacific (Gulf of Alaska and West Coast) and Bering Sea/Aleutian Islands sub-tasks, respectively. Scientists at AFSC assist in preparation of stock assessment documents for groundfish in the three management regions (Bering Sea/Aleutian Islands, Gulf of Alaska, and Washington-Oregon-California), conduct research to improve the precision of these assessments, and provide management support through membership in regional groundfish management teams. Two stock assessment documents were prepared for West Coast stocks and 15 assessments were prepared for Gulf of Alaska and Bering Sea/Aleutian Islands stocks.

NMFS - AFSC - AUKE BAY LABORATORY

The Auke Bay Laboratory (ABL) groundfish task (part of ABL's marine fisheries assessment program) has focused its efforts since 1982 on research and assessment of sablefish and rockfish in the Gulf of Alaska. Presently, the groundfish task is staffed by 10 permanent and 1 temporary biologist. In 1991 field research, ABL's groundfish task participated in two longline surveys that primarily assessed sablefish abundance in the Gulf of Alaska: 1) the annual Japan-U.S. cooperative longline survey, and 2) the annual domestic longline survey. ABL also conducted a sablefish population experiment in Chatham Strait, southeastern Alaska, in cooperation with the Alaska Department of Fish and Game (ADF&G). Other major field activities included a submersible/trawl study of slope rockfish in the eastern Gulf of Alaska, and early life history studies of sablefish and rockfish.

Several analytic activities were conducted by groundfish task members on sablefish and rockfish in 1991-92. A hook competition model was developed to provide improved estimates of sablefish abundance from longline surveys. The "stock synthesis" model was applied to sablefish to provide alternative estimates of biomass and recruitment. An age and growth study of northern and dusky rockfish in the Gulf of Alaska was completed. A parasite study of shortraker and roughey e rockfish is currently in progress to determine if parasites can be used to identify stocks of these species in the Gulf of Alaska. Task members also prepared three status of stock documents for Gulf of Alaska groundfish: sablefish, slope rockfish, and pelagic shelf rockfish. Other ongoing research activities included a sablefish tag recovery program, analysis of data on migration and growth of juvenile sablefish, and food of adult and immature sablefish.
B. Multispecies Studies

1. Research

Bering Sea Crab/Groundfish Survey

An expanded bottom trawl survey was conducted in the eastern Bering Sea, covering the upper continental slope, the north shelf up to St. Lawrence Island, Norton Sound, and the standard survey area of the southeast shelf. The Ocean Hope 3 and Alaska sampled the southeast shelf and north shelf from June 4 to August 18 and the Ocean Hope 3 sampled Norton Sound from August 12 to September 3. All stations were sampled with a 83-112 eastern trawl. Catches were sorted to species level, weighed and enumerated. Fish lengths and crab carapace widths were measured and age structures were collected.

The Miller Freeman sampled 94 stations on the eastern Bering Sea slope from August 31 to Sept. 27 with a polyethylene Norvalen trawl net equipped with roller gear. Catches were analyzed as above except that no crab carapace widths were taken.

Other research conducted during the survey included collections of:
1) stomachs from various groundfish species for food habit studies,
2) fish specimens for identification training,
3) skates for meristic studies to develop a key to the species of the eastern Bering Sea,
4) individual pollock weights for developing relationships to age and length,
5) liver samples and lamprey scar counts on pollock from the slope for stock separation study,
6) otoliths from Pacific halibut in the standard survey area and otoliths and pituitaries on the continental slope,
7) a variety of pathology samples, including tissues from red and blue king crab for studying a microsporidian (Thelohania sp.) and a Herpes-like virus, tissues from tanner crabs for studying a parasitic dinoflagellate (Hematodinium sp.) and a fungal pathogen, bloodsmears from tanner crabs to study Hematodinium, and tissues from 4 dungeness crab,
8) separate catch data and otoliths from arrowtooth and Kamchatka flounder to determine if there are significant differences in their growth and distribution, and
9) maturity stage data and 100 pairs of ovaries from yellowfin sole for histological examination of ovarian development.

Blue king crab were also tagged near St. Matthew Island to study their growth and migration. In conjunction with the main survey, a nearshore beam trawl survey was conducted along the Alaska Peninsula and in inner Bristol Bay to examine potential long-term monitoring sites for juvenile red king crab and juvenile flatfish. Beam trawl hauls were successfully completed at 75 stations and 2 scallop dredge tows were completed during this investigation.

Preliminary results of the 1991 survey, comparing the biomass estimates in the standard survey area to the 1990 survey, indicate a change in the population estimates for several species. Biomass estimates of commercially important roundfish such as pollock (-33%) and Pacific cod (-25%) are down considerably from last year. There was generally little change in biomass estimates for small flatfish species such as rock sole (+13%), yellowfin sole (+10%), Alaska plaice (+6%), and flathead sole/Bering flounder (-12%).

Estimates of large flatfish species such as arrowtooth flounder/Kamchatka flounder were lower (-14%), Greenland turbot continued to decline (-24%) while biomass of Pacific halibut was up slightly (+9%).
Joint U.S.-U.S.S.R. survey

Just prior to the NMFS survey of the eastern Bering Sea, the R/V Novodrutzk, a vessel of the former U.S.S.R., began a cooperative bottom trawl survey. They covered the standard area of the eastern Bering sea and continued across the treaty line to Soviet waters at Cape Navarin and westward past Cape Olyutorski to Karaginski Island. This survey was conducted from May 11 to June 25, covering alternate rows of U.S. stations with a much larger net (94 m footrope compared to 34 m footrope) than in the NMFS survey. This was similar to the 1990 cooperative survey conducted by the R/V Novokotovsk, but the 1991 survey was limited in coverage of the north shelf by ice, and continued west of Cape Olyutorski. Five U.S. scientists participated in the survey.

The biomass estimates of several commercially important species in the standard (annual coverage) Bering Sea survey area from the last two U.S. and Soviet surveys are listed for comparison in Table 1. The total biomass of the Soviet catches of species selected for comparison was 50% of the U.S. biomass estimate. Exceptions were Pacific cod, which was higher in the Soviet survey, and Pacific halibut and Greenland turbot catches, which were approximately the same as in the U.S. survey. Especially noteworthy were low catches of Tanner crabs and king crabs in the 1991 Soviet survey. The 1990 Soviet survey also had generally lower catches than the 1990 U.S. survey. Since the U.S. and Soviet surveys were conducted with different vessels using different nets, at different times of year, it is uncertain how to compare the survey data.

Table 1. Comparison of 1990 and 1991 Soviet and U.S. survey biomass estimates (metric tons) of selected groundfish and crabs in the standard Bering Sea survey area.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollock</td>
<td>3,153,300</td>
<td>7,653,400</td>
<td>3,070,300</td>
<td>5,109,000</td>
</tr>
<tr>
<td>Pacific cod</td>
<td>656,500</td>
<td>708,600</td>
<td>716,700</td>
<td>532,600</td>
</tr>
<tr>
<td>Subtotal</td>
<td>3,809,753</td>
<td>8,361,984</td>
<td>3,786,991</td>
<td>5,641,559</td>
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<tr>
<td>Yellowfin sole</td>
<td>2,429,100</td>
<td>2,183,800</td>
<td>805,800</td>
<td>2,393,300</td>
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<tr>
<td>Rock sole</td>
<td>1,304,100</td>
<td>1,409,000</td>
<td>792,100</td>
<td>1,588,300</td>
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<tr>
<td>Flathead sole</td>
<td>333,100</td>
<td>646,000</td>
<td>272,200</td>
<td>570,300</td>
</tr>
<tr>
<td>Alaska plaice</td>
<td>679,400</td>
<td>525,800</td>
<td>238,500</td>
<td>529,100</td>
</tr>
<tr>
<td>Other flatfish</td>
<td>48,100</td>
<td>46,600</td>
<td>15,100</td>
<td>73,900</td>
</tr>
<tr>
<td>Subtotal</td>
<td>4,793,860</td>
<td>4,811,170</td>
<td>2,123,727</td>
<td>5,154,946</td>
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<tr>
<td>Skates</td>
<td>269,600</td>
<td>573,900</td>
<td>202,200</td>
<td>464,400</td>
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<tr>
<td>Arrowtooth flounder</td>
<td>255,900</td>
<td>454,100</td>
<td>155,400</td>
<td>389,900</td>
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<tr>
<td>Pacific halibut</td>
<td>99,800</td>
<td>89,500</td>
<td>95,700</td>
<td>97,600</td>
</tr>
<tr>
<td>Greenland turbot</td>
<td>3,200</td>
<td>14,100</td>
<td>10,000</td>
<td>10,700</td>
</tr>
<tr>
<td>Subtotal</td>
<td>628,341</td>
<td>1,131,669</td>
<td>463,321</td>
<td>962,189</td>
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<tr>
<td>Sculpins</td>
<td>156,052</td>
<td>224,145</td>
<td>133,600</td>
<td>272,973</td>
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<tr>
<td>Tanner crab</td>
<td>832,800</td>
<td>947,800</td>
<td>68,400</td>
<td>1,017,200</td>
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<tr>
<td>King crab</td>
<td>47,100</td>
<td>84,000</td>
<td>6,600</td>
<td>106,700</td>
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<tr>
<td>Subtotal</td>
<td>879,815</td>
<td>1,031,790</td>
<td>74,971</td>
<td>1,123,827</td>
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<tr>
<td>Total</td>
<td>10,267,821</td>
<td>15,560,758</td>
<td>6,582,610</td>
<td>13,155,494</td>
</tr>
</tbody>
</table>

Perhaps the most valuable data from the 1991 Soviet survey is the catch data off the Soviet coast between Cape Olyutorski and Karaginski Island, which
was not examined in a joint survey before. Although the biomass estimates may not be directly comparable to other surveys, the catch data were compared between subareas by the relative catch rate. Catches on the Soviet side may be of concern to U.S. fishermen as they enter into agreements to venture across the Bering sea and fish in the Soviet Exclusive Economic Zone. Catch rates were much lower on the Soviet side than on the U.S. shelf for small flatfish species such as rock sole, Alaska plaice, yellowfin sole and flathead sole/ Bering flounder. Skates and larger flatfish, such as arrowtooth/Kamchatka flounder were also less abundant on the Soviet side. Catch rates of Greenland turbot were relatively high in some Soviet subareas. Catch rates of Pacific halibut were also relatively high between Cape Navarin and Karaginski Island.

There were several high catch rates of roundfish on the Soviet side, including Pacific cod and pollock. Overall catch of pollock on the Soviet side was about the same (69.4 kg/ha) as for the U.S. standard area (66.26 kg/ha).

Overall, catch rates of invertebrates were very low in this survey in comparison to the 1991 U.S. survey, and both the Soviet and U.S. surveys from 1990. The low catch rates of king and tanner crabs yielded a combined biomass estimate of less than 7% of the estimated biomass from the 1991 U.S. survey. Apparently the gear did not function well for sampling crabs and other invertebrates.

(Gary Walters, (206) 526-4104)
Table 2. Relative catch rates of subareas in kg/ha for the 1991 Novodrutsk survey.

<table>
<thead>
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<th>Species</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<th>16</th>
<th>17</th>
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<tr>
<td>Skates</td>
<td>.05</td>
<td>0</td>
<td>3.37</td>
<td>2.85</td>
<td>11.03</td>
<td>9.88</td>
<td>7.72</td>
<td>.23</td>
<td>5.41</td>
<td>.16</td>
<td>.82</td>
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<tr>
<td>Arrowtooth</td>
<td>0</td>
<td>0</td>
<td>2.46</td>
<td>0.44</td>
<td>13.00</td>
<td>7.92</td>
<td>0.05</td>
<td>0</td>
<td>0.18</td>
<td>0.07</td>
<td>0.14</td>
</tr>
<tr>
<td>Greenland t.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.06</td>
<td>0</td>
<td>0.99</td>
<td>0.34</td>
<td>0.04</td>
<td>0.57</td>
<td>0</td>
<td>0.32</td>
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<tr>
<td>P. halibut</td>
<td>0.82</td>
<td>0.56</td>
<td>2.48</td>
<td>1.69</td>
<td>4.09</td>
<td>2.89</td>
<td>0.13</td>
<td>0</td>
<td>0.82</td>
<td>3.43</td>
<td>3.40</td>
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<tr>
<td>Flathead sole</td>
<td>0.14</td>
<td>0.08</td>
<td>12.89</td>
<td>2.12</td>
<td>4.91</td>
<td>10.12</td>
<td>5.84</td>
<td>3.63</td>
<td>3.36</td>
<td>0.11</td>
<td>1.11</td>
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<td>Yellowfin sole</td>
<td>27.60</td>
<td>42.11</td>
<td>16.85</td>
<td>22.63</td>
<td>0.01</td>
<td>0.01</td>
<td>0.03</td>
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<td>0</td>
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<td>Rock sole</td>
<td>34.54</td>
<td>8.58</td>
<td>16.34</td>
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<td>5.06</td>
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<td>12.23</td>
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<td>10.11</td>
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<td>173.02</td>
<td>9.01</td>
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<td>0.23</td>
<td>0</td>
<td>0.01</td>
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<td>Squid</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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United States
Southeastern Bering Sea

Former U.S.S.R.
North
Western Bering Sea
Bottom Trawl Survey of the Aleutian Islands

The fourth triennial bottom trawl survey of the Aleutian Islands region was completed during the summer of 1991 by the RACE Division of the AFSC. The triennial groundfish surveys are designed to describe and monitor the distribution, abundance, and biological condition of the important groundfish stocks in the Aleutian Islands area. Previous surveys in this series were conducted in 1980, 1983 and 1986. Historically, the Aleutian Islands have been important fishing grounds for a variety of groundfish species including Pacific ocean perch, Atka mackerel, walleye pollock, Pacific cod, Pacific halibut, sablefish, rockfishes, and several invertebrate groups, including crabs and squid.

The survey was conducted aboard two chartered commercial trawlers, the Ocean Hope 1 and the Green Hope from July 17 to September 27, 1991. The survey area covered a portion of the southern Bering Sea, from 165°W long. to 170°W long. and throughout the Aleutian Islands from 170°W long. to Stalemate Bank 170°30'E long. Sampling proceeded from east to west at pre-selected stations at depths ranging from 9 to 285 fm (16-521 m).

The stratified random survey design used for the 1983 and 1986 triennial surveys was employed during 1991 to make the most efficient use of limited vessel time and to provide consistency with earlier surveys. The area was stratified based on historical abundance of major commercial species and by depth. A total of 452 stations were randomly selected from a pool of previously successful stations. The proportion of the total available sampling effort allocated to each minor subarea-depth interval was consistent with past surveys. To ensure complete geographical coverage, each minor subarea-depth interval was sectioned into longitudinal strips.

Standard trawl hauls were 30 minutes in duration. Efforts were made to maintain each tow at a constant depth. Catches were sorted to species, weighed and enumerated according to standard AFSC and RACE Division protocol. A variety of biological data (age, length, sex, weight, and maturity of individual specimens) were taken. Special requests were also fulfilled for stomach, tissue, and whole fish samples.

Successful trawls were achieved at 350 of the 379 stations attempted. A total of 108 fish species were identified in survey catches. In addition to the groundfish species, catches also contained representatives from numerous invertebrate orders. In the Aleutian Islands, Atka mackerel, Pacific ocean perch, northern rockfish, walleye pollock, and Pacific cod dominated the catches in most strata. The largest fish concentrations encountered during the survey were in the western Aleutian Islands (west of 180°W) and were composed primarily of Atka mackerel, Pacific ocean perch, and northern rockfish. Catches in the eastern Aleutian Islands were represented mainly by Atka mackerel, Pacific ocean perch, and walleye pollock. Pacific cod were relatively evenly distributed throughout the survey area. Important components of catches from the southern Bering Sea portion of the survey were walleye pollock, arrowtooth flounder, Pacific cod, and rock sole.

(Eric Brown, (206) 526-4157)

West Coast Continental Slope Research Survey

The RACE Division conducted a bottom trawl survey of the upper continental slope groundfish resources in the INPFC Monterey area aboard the Miller Freeman between October 25 and November 18, 1991. The primary objectives of the survey were to describe the community structure and biological characteristics of the groundfish stocks of the continental slope in the northern segment of the INPFC Monterey area and to resurvey stations in the 300-399 fm zone of the INPFC Columbia and Eureka areas to resolve apparent anomalies observed during past surveys. Successful trawl hauls were completed at 66 of the primary survey stations in the Monterey area. Twenty-six additional successful hauls were completed in the Columbia and Eureka area resurvey project. We also collected shortbelly rockfish specimens for the
Tiburon Lab of the SWFSC with 4 targeted midwater tows in the San Francisco area and made 7 phytoplankton tows to obtain specimens for studies of domoic acid toxins.

Concern arose when the 1990 continental slope bottom trawl survey showed that catch rates of sablefish and longspine thornyhead in the Eureka area were markedly lower than those observed in adjacent areas to the north in 1988 and 1989. To determine whether this represented real changes in density, trawl samples were obtained at resurvey stations (300-399 fm) in both areas. The Columbia area catch rates for sablefish, longspine thornyhead, and Dover sole from this year's resurvey in the Columbia area were markedly lower than in 1989; the mean catch rate of shortspine thornyhead, however, increased. The Eureka area catch rates for these species remained about the same in 1990 and 1991, except for an increase in longspine thornyhead in 1991. Successful trawl samples were obtained from 70 of 73 Monterey area stations. Dover sole was the most abundant species overall in the Monterey area, taken in all strata. It was the most abundant species in the 200-400 fm strata and was among the four most abundant species all but one of the other depth strata. Longspine thornyhead was the second most abundant species, taken in all except the shallowest stratum. It was the most abundant species between 400 and 600 fm. Pacific hake was very abundant inside 400 fm and ranked third in abundance over all depths. Sablefish catch rates were relatively consistent over all depth strata, making it the fourth most abundant species overall. Pacific grenadier, grooved Tanner crab, shortspine thornyhead, and giant grenadier were also important components of the overall catch.

Otoliths and data on individual length, weight, and maturity stage were collected from sablefish, Dover sole, shortspine and longspine thornyhead. Stomach samples were collected from six slope groundfish species for feeding habits studies and, 83 juvenile sablefish were tagged, injected with OTC, and released in good condition in the study area. Oceanographic data (CTD or XBT water column profiles) were obtained at most stations.

Sablefish and rockfish early life history studies

Two ichthyoplankton sampling cruises were conducted by ABL using the RV John N. Cobb in waters offshore southeastern Alaska in May and June 1991. Sablefish larvae were found most abundant 140-160 km offshore in neuston tows taken during the May cruise. Although sablefish catches were not as high in 1991 as in a similar cruise in 1990, they were still the most abundant (up to 960 per 15 minute tow) and most frequent (20 of 26 stations) fish larvae in the neuston samples. These observations confirm that early life history stages of sablefish in the eastern Gulf of Alaska depend on the offshore pelagic habitat. Foul weather restricted the June 1991 sampling to only 10 stations along 57°N. Sablefish were much fewer in the June samples but still restricted to those stations furthest offshore.

As in 1990, rockfish were among the most numerous fish larvae taken in oblique bongo tows during the May and June 1991 cruises. All rockfish larvae were preflexion stage and could not be identified to species, although several distinct pigment patterns were present.

Age and Growth Task - REFM

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, data manager/technician, and 10 age readers (2 positions are currently empty). Ages are usually determined from otoliths, scales or finrays.
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, Pacific Ocean perch, rougheye rockfish, misc. rockfish sp., Atka mackerel, yellowfin sole, and rock sole.

Craig Kastelle received a M.S. in Fisheries in August, 1991, for his thesis titled "Radioisotope age validation and an estimate of natural mortality from the gonad to somatic weight index for sablefish (Anoplopoma fimbria). The highlight of the thesis was validation of ageing criteria for sablefish using the radiometric technique. The possibility of further radiometric work is being considered for rockfish species.

We have recently completed a paper which "Examines the effects of year-class strength on age determination" for walleye pollock. This paper will appear in a special age and growth issue of the Australian Journal of Marine and Freshwater Research.

(Dr. Daniel K. Kimura (206) 526-4200)

Food Habits Studies - REFM

The Food Habits Program continued regular collection of food habits information on key fish predators in the North Pacific. Program personnel and fishery observers collected fish stomachs. About 9455, 2647, and 847 stomachs were collected from the Bering Sea, Aleutian Islands and Wash.-Ore.-Calif. coast, respectively. Bering Sea species sampled were walleye pollock, Pacific cod, yellowfin sole, Alaska plaice, rock sole, flathead sole, arrowtooth flounder, Greenland turbot and Pacific halibut. Aleutian Islands species sampled included walleye pollock, arrowtooth flounder, Pacific cod, Pacific halibut, sablefish, Pacific ocean perch, and miscellaneous rockfish species. West coast species sampled were Pacific hake, sablefish, longspine and shortspine thornyhead, deep sea sole, and Dover sole. Shipboard scans of fish stomach contents were performed on 993 fish (primarily walleye pollock) in the eastern Bering Sea and Gulf of Alaska. Laboratory analysis of stomach contents by regions totalled 4637, 1885, and 615 stomachs for the Bering Sea, Gulf of Alaska and West coast regions, respectively.

Food habits data from yellowfin sole, flathead sole, and Pacific cod from the Bering Sea were examined to determine the location, size, and timing of Tanner crab consumed with the intent of examining the usefulness of the data as growth and abundance indicators for early Tanner crab instars. There was too much variability in the appearance of a given instar in stomach contents across months to use the data to track abundant instar groups and their molts. Bering Sea groundfish diet information was provided to University of Alaska researchers examining Bering Sea food webs. Groundfish predation data from 1987 and 1988 in the eastern Bering Sea was summarized and trends in consumption of walleye pollock and herring by groundfish were examined for the time period of 1985 to 1988. Groundfish predation on walleye pollock during this time period was dominated by cannibalism on age-0 walleye pollock by adults. Highest predation rates during the 4 years occurred in 1985, which coincided with the higher 1985 pollock year-class size (relative to 1986 through 1988) as predicted by cohort analysis estimates of year-class size at age 3 and trawl survey estimates of the 1985 year-class size at age 1. Estimated numbers of a particular year-class of pollock consumed at age 0 by groundfish predators were highly correlated both with cohort analysis estimates of year-class size at age and trawl survey estimates of year-class size at age 1. Herring consumption by groundfish predators tended to be sporadic in time and space and may depend on encounter rates of herring schools rather than overall biomass. No particular age group of herring was consumed although Pacific cod ate large numbers of age 1 herring. Sizes eaten by groundfish mainly ranged from 19 to 30 cm. Pacific cod tended to be the most consistent predator on herring, consuming herring in all four years. Herring were consumed by cod in widely scattered locations on the eastern Bering Sea shelf from May to September. During
winter, herring consumption by cod was observed only near the continental slope between 59–60°N latitude. Other groundfish predators on herring were walleye pollock, arrowtooth flounder, and Greenland turbot. Consumption by these predators occurred in only 1 or 2 of the 4 years sampled. There was no apparent relationship between biomass of herring consumed by groundfish predators and cohort analysis estimates of herring biomass in a given year.

The Japanese groundfish food habits data base, which contains data collected from 1970 to 1985 in the Bering Sea was restructured and converted into a format similar to the Food Habits Program data base to allow the use of our data analysis programs. Unfortunately, the data were collected in different geographic areas over time and have very few recorded prey lengths. Only 104 lengths of prey pollock cannibalized by adults were recorded for the 15 year time span and, given the variable areas covered, greatly limit the ability to calculate total cannibalism by year.

(Pat Livingston, (206) 526-4242)

Observer Program - REFM

The Fisheries Observer Program is responsible for placement of observers on foreign and domestic vessels fishing in the EEZ of the northeastern Pacific Ocean and Bering Sea. Observers collect data which provide the basis for in-season management of foreign, joint venture and domestic fisheries by NMFS, and a means for evaluating and developing management strategies by regional management councils and NMFS. Observers play important roles in monitoring compliance to U.S. fishing regulations and provide information that is useful in promoting development of the U.S. fishing industry.

During 1991, no foreign vessels were allowed to catch or process fish in the U.S. EEZ along the west coast and Alaska. All of the allotted groundfish were given to U.S. vessels and processing plants, both for catching and processing. The Observer Program trained and deployed 429 observers to domestic vessels fishing off Alaska, and 31 observers to domestic 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. These data were also used in the implementation of the Vessel Incentive Program in Alaska, where vessels were prohibited from exceeding certain prohibited species catch standards. Valuable data were also collected regarding the operations of the domestic groundfish fishery.

(Russell Nelson, (206) 526-4194)

C. By species, by agency

1. Pacific cod

b. Assessment

Bering Sea/Aleutians

Pacific cod in the EBS and Aleutian Islands are managed as a unit, although nearly all of the assessment research focuses on the EBS portion of the stock. Annual trawl surveys indicate that the biomass of Pacific cod in the EBS remained high and stable throughout the 1980s. However, the 1990 survey showed a 26% drop in biomass relative to 1989, and the 1991 survey showed a 25% drop in biomass relative to 1990. Concern has been expressed over this decline and the poor recruitment observed during the past three years. It has further been noted that the stock’s dynamics may be entering a new phase defined by different environmental conditions or ecological
relationships. However, the 1990 and 1991 surveys also show evidence of stronger-than-average year classes that will recruit at age 3 in 1992 and 1993.

The stock assessment model used to calculate ABC for Pacific cod in the EBS was retuned for the 1991 assessment, incorporating survey and catch data from 1991 and an expanded supply of age data. This resulted in new estimates for all parameters estimated by the model, and led to the conclusion that reliable values for MSY, $F_{M\text{SY}}$, and $B_{M\text{SY}}$ were no longer available. Because the model is tuned to the survey results, it showed a decline in biomass between 1990 and 1991. However, the decline indicated by the model was smaller than that indicated by the survey (8% vs. 25%, respectively).

The EBS cod model calculates ABC by applying the target exploitation rate (in this case the $F_{0.1}$ rate, 0.145) to projected biomass through a complex schedule of age- and time-dependent fishing mortality rates. This procedure produced a 1992 ABC of 162,000 t for the EBS portion of the stock, which was scaled upward by a factor of 1.124 to give a 1992 ABC of 182,000 t for the EBS and Aleutian Islands combined.

Because reliable estimates of $F_{M\text{SY}}$ and $B_{M\text{SY}}$ are no longer available for the EBS Pacific cod stock, overfishing is defined to occur at the fishing mortality rate that reduces the biomass-per-recruit ratio to 30% of its pristine value. This fishing mortality rate is 0.149, which corresponds to a 1992 catch of 188,000 t for the EBS and Aleutians combined.

The Gulf of Alaska stock yielded a catch of 81,100 t in 1991, surpassing the previous record of 78,300 t set in 1990. The stock reduction analysis used to assess this management unit was recalibrated, incorporating new estimates of growth, discard, and natural mortality parameters. As in the two previous assessments, a correction factor was used to allow the model to exhibit continuous growth and continuous harvest simultaneously. The $F_{0.1}$ harvest strategy ($F=0.18$) was used to set both ABC and TAC, giving a projected 1992 catch of 63,500 t. Overfishing is defined to occur at $F=0.25$, or a 1992 catch of 87,600 t.

(Dr. Grant Thompson at (206) 526-4232)

2. Shelf rockfish
   a. Research

Age and Growth of Northern and Dusky Rockfish

Age-length samples collected during the 1984 and 1987 trawl surveys were analyzed to provide the first break and burn estimates of maximum age and growth parameters for northern and dusky rockfish in the Gulf of Alaska. Based on a sample of 853 aged fish, maximum age of northern rockfish was 49 years with estimated von Bertalanffy parameters of $L_w = 35.6$ cm; $K = 0.19$; and $t_0 = -1.51$. Based on a sample of 488 aged fish, maximum age of dusky rockfish was 49 years with computed von Bertalanffy parameters of $L_w = 47.9$ cm; $K = 0.14$; and $t_0 = -2.72$.

(Jonathan Heifetz (206)526-4165)

b. Assessment

Gulf of Alaska

The pelagic shelf rockfish assemblage is 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. Dusky rockfish appears to be the most abundant species in the group. Current exploitable biomass for the pelagic shelf assemblage is based on the average of the biomasses estimated in the 1984, 1987, and 1990 triennial trawl surveys: 76,501 mt. Similar to slope
rockfish, however, results of all these surveys are highly uncertain, especially when applied to species that may be somewhat pelagic in distribution. Pelagic shelf rockfish are presently managed using an F=M strategy, in which the annual exploitation rate is set equal to the rate of natural mortality. Based on the recent age and growth study for dusky rockfish, natural mortality of dusky rockfish is estimated to be 0.09. Applying this exploitation rate to the current exploitable biomass yields a Gulfwide ABC of 6,886 mt for 1992.

In 1991, a small boat jig fishery for black rockfish (one of the species in the pelagic shelf group) developed in the central Gulf of Alaska in the Kodiak-Kenai Peninsula area. This fishery took a sizeable proportion of the reported catch for pelagic shelf rockfish in this region. To prevent future selective overexploitation of this species, the Gulf of Alaska Groundfish Plan Team recommended that black rockfish be split from the pelagic shelf assemblage, and that it be assigned a separate value of total allowable catch. The North Pacific Fishery Management Council decided, however, that there were insufficient data to enact this recommendation in 1992.

(Dave Clausen (907)789-6049)

3. Slope rockfish
   a. Research

Submersible/Trawl Studies of Slope Rockfish

The NOAA research vessel John N. Cobb, the manned submersible Delta, and the submersible tender MV Pirateer completed a 12-day combined cruise on 16 June 1991. Study sites, located offshore of Iphigenia Bay in Southeastern Alaska to Yakutat Valley in the northern Gulf of Alaska, were surveyed from the submersible to determine the numbers, spatial distribution, and habitat of offshore rockfish. Selected sites were then trawled by the RV John N. Cobb to confirm identities and quantities of fish observed visually from the submersible. Nine submersible/trawl comparisons were made in 1991, adding to the nine similar comparisons made in 1990. Observations from 30 submersible dives in 1991 confirmed the behavior and habitats occupied by rockfish on 20 previous dives in 1988 and 1990. Depths of submersible dives ranged from 188 to 365 m. Counts of Pacific ocean perch and other rockfish, as well as comments made by personnel aboard the submersible and tender vessel, were recorded on video tape along 4 transects across a rectangle 0.25 nmi wide by 0.3 nmi long. Observation along the transects was limited to 7 m distance as determined by a portable sonar gun.

Submersible observations of fish behavior and habitats provided insight as to the vulnerability of fish to trawl gear. Most Pacific ocean perch were in groups of 2-200 individuals located over flat, pebble substrate. Individual fish within the group were 1-4 m apart, usually oriented into the current, and distributed 0-7 m above the bottom. When approached closely, these fish dove for the bottom. Shortraker rockfish were on 3-12° sloping terrain comprised of silt or pebbles interspersed with boulders. These fish were on or near the bottom, solitary, and showed little or no reaction to the close approach of the submersible. Other Sebastes spp. were associated with rugged habitat such as cobble, boulders, and coral.

Densities of rockfish estimated from bottom trawl catches were higher than densities observed from the submersible, indicating that the trawl gear herded rockfish into the opening of the trawl. This possible herding effect and the preference of Pacific ocean perch for smoother substrate may result in systematic overestimates of abundance for this species in bottom trawl surveys.

(Ken Krieger 907-789-6053 or Dick Haight 907-789-6052)
Parasite Study of Shortraker and Rougheye Rockfish

Parasites often have proven useful as biological markers for separating stocks of fish. Autopsies are currently underway on shortraker and rougheye rockfish collected in the 1991 domestic longline survey to assess the use of parasites in identifying stocks of these two species. Initial results suggest that the prevalence of acanthocephalans is highest and cestodes and nematodes are lowest in the central Gulf of Alaska. Gill and gut parasites show promise for separating stocks within Alaska and appear quite different from parasite species reported from Canadian rockfish.

(Adam Moles (907)789-6023)

b. Assessment

Bering Sea

Pacific Ocean Perch

Results from recent stock assessments, indicate that recruitment has improved. This has resulted in an increasing trend in biomass in both regions, particularly in the Aleutian Islands region. Overlapping confidence intervals between the trawl survey point estimates, however, indicate that this trend may not be statistically significant. Because of the uncertainty regarding trawl survey biomass estimates, alternative survey methodologies are presently being explored that may lead to improved estimates in the future (e.g., as describe in the AFSC’s Rockfish Working Plan).

Previously, the NPFMC assigned a single ABC annually for the Pacific ocean perch complex. This complex is comprised of Pacific ocean perch, northern rockfish, rougheye rockfish, shortraker rockfish, and sharpchin rockfish. Recent evidence indicates that commercial fishermen may be targeting upon certain species in the complex, especially shortraker and rougheye rockfish. There is an economic incentive to target on rougheye and shortraker rockfish because they command a much higher ex-vessel price than the other species in the complex. The ability and tendency of the commercial fishery to target on these species poses a major conservation concern. To prevent possible depletion of these more desirable species, the NPFMC in 1991 divided the Pacific ocean perch complex into management subgroups.

In the eastern Bering Sea region, the Pacific ocean perch complex has been divided into two subgroups -- a subgroup containing S. alutus only and a subgroup containing shortraker, rougheye, sharpchin, and northern rockfishes combined. In the Aleutian Islands region, the Pacific ocean perch complex has been divided into three subgroups -- a subgroup containing S. alutus only; a subgroup comprised of shortraker and rougheye rockfishes; and a subgroup containing northern and sharpchin rockfishes. Separate ABC’s are now assigned to each management subgroup.

(Daniel Ito at (206) 526-4231)

Gulf of Alaska

Slope rockfish are defined as those species of Sebastes that, as adults, inhabit waters of the continental slope, generally in depths greater than 150-200 m. Twenty species of rockfish are classified into the slope assemblage, the most abundant of which are Pacific ocean perch, and northern, rougheye, sharpchin, redstripe, harlequin, and shortraker rockfish. The stock abundance of slope rockfish is considered to be depressed compared to its former abundance in the early 1960’s. Recent stock assessments have been based mostly on triennial trawl surveys of the Gulf, the results of which are uncertain. The 1987 survey indicated stock abundance was increasing, whereas the 1990 survey showed a sharp decline. Because of the uncertainty regarding
these surveys, exploitable biomass of slope rockfish is presently based on the average of the two surveys, and is estimated at 532,575 mt.

To prevent possible overexploitation of the more desirable species, the slope rockfish assemblage is divided into three subgroups: Pacific ocean perch, shortraker/rougheye rockfish, and other slope rockfish. Separate ABC's are assigned to each subgroup. The subgroups are managed under an F=M strategy, in which the annual exploitation rate is set equal to the rate of natural mortality. For the Pacific ocean perch subgroup, the F=M exploitation rate is reduced by 50% to conform with the North Pacific Fishery Management Council's definition of overfishing. The 1992 ABCs are as follows: Pacific ocean perch, 5,730 mt; shortraker/rougheye rockfish, 1,960 mt; and other slope rockfish, 14,060 mt.

(Jonathan Heifetz (206)526-4165)

West Coast

Pacific Ocean Perch

A rebuilding program was established for Pacific ocean perch in 1981 following depletion of this stock during the 1960s and early 1970s. An assessment in 1987 indicated that the stock remained depleted. A review in 1990 of recent commercial fishery length data did not indicated any significantly strong year classes entering the fishery. The research surveys, which generally capture younger fish did indicate some evidence of incoming strong year classes, although none rivalled the magnitude of the 1970 cohort. This signal is encouraging, but significant rebuilding has not occurred. A new assessment of the Pacific ocean perch resource will be conducted in 1992. This assessment will employ the stock synthesis model for the first time and will simultaneously examine all of the available fishery and research data. The results should prove useful in providing a status report to the Council regarding its rebuilding program and provide the necessary information for establishing future harvest levels.

(Daniel Ito at (206) 526-4231)

4. Thornyheads

b. Assessment

Gulf of Alaska

Thornyheads are managed under the North Pacific Fishery Management Council's Gulf of Alaska Groundfish Fishery Management Plan. Catches were exclusively foreign in the late 70's and early 80's and were less than 1,400 t. With the decrease in foreign quota in the Gulf catches deceased in the mid 1980s before peaking in 1989 at 3,079 t as the domestic fishing industry grew. Catches have decreased to 1,646 t in 1990 and 1,168 t in 1991.

Based on trawl survey data in the Gulf of Alaska abundance of thornyheads has sharply declined from 99,000 t in 1987 to 26,000 t in 1990. There is no evidence the fishery is responsible for the decline. Since the abundance of thornyheads was first measured in 1984, landings have never exceeded 6.5% of the best interpolated estimate of biomass and throughout 1984-1988 landings did not exceed 4%. The stock is fully utilized and is harvested under an F=M strategy. In 1992 the Acceptable Biological Catch is 1,800 t.

(Pierre Dawson (206) 526-4245)
5. Sablefish

a. Research

Gulf of Alaska

Japan-U.S. Cooperative Longline Survey

For the fourteenth consecutive year, a cooperative longline survey was conducted in the Aleutian Islands region, Bering Sea, and Gulf of Alaska by Japan and the United States. The primary objective was to obtain indices of sablefish and Pacific cod abundance, assessment of other major catch components such as Pacific halibut, arrowtooth flounder, Greenland turbot, rockfish, thornyheads, and grenadiers; to tag sablefish; and to collect biological information about sablefish. The 1991 survey used the Anyo Maru No. 22, a commercial Japanese longline vessel provided by the North Pacific Cooperative Fisheries of Japan. A scientist from the AFSC's RACE division participated in the cruise in the western Gulf of Alaska, and one from ABL in the eastern Gulf of Alaska. As in previous years, 47 stations were fished along the upper continental slope of the Gulf from the eastern Aleutian Islands to Dixon Entrance. At each station, one longline 16 km long containing 7,200 hooks was set and retrieved.

Sablefish and Pacific cod made up most of the total catch. Sablefish were most abundant in the Gulf of Alaska, and Pacific cod were most abundant in the eastern Bering Sea. Compared to the 1990 cooperative longline survey catches of sablefish declined substantially in the Aleutians and especially in the eastern Bering Sea, where catches declined by over 50%. In the Gulf of Alaska, sablefish relative population number (RPN) declined by 2.6% for the upper continental slope from 1990 to 1991. This slight decrease was not statistically significant and it indicates that the population of sablefish remained relatively stable over this time. When compared with the survey results for the years 1984-88, however, it appears that sablefish abundance has substantially declined. The survey catches of Pacific cod were similar in the Aleutians between 1990 and 1991, but declined by 23% in the eastern Bering Sea.

For the second consecutive year, the cooperative survey showed results that were markedly different from the results seen in the 1991 domestic longline survey. The domestic survey indicates relative abundance of sablefish in the Gulf of Alaska is much higher than that observed in the cooperative survey. Both surveys are planned to continue in 1992, which will provide another year of comparisons.

(David Clausen (907)789-6049 and Eric Brown (206)526-4157)

Domestic Longline Survey

The AFSC has conducted an annual longline survey of sablefish and other groundfish in the Gulf of Alaska from 1987-91. The survey is a joint effort involving ABL and the RACE Division. As in past surveys, the primary objective was to determine the relative abundance and size composition of four slope-resident groundfish species: sablefish, shortspine thornyhead, and rougheyes and shortraker rockfishes, and secondarily to determine the relative abundance and size compositions of other species such as Pacific cod, grenadiers (Macrouridae), arrowtooth flounder, and Pacific halibut. It replicates as closely as practical the Gulf of Alaska portion of the Japan-U.S. cooperative longline survey conducted from 1978-91 and also samples gullies not sampled by the cooperative longline survey. Sixteen kilometers of groundline are set each day, containing 7,200 hooks baited with squid. In 1991, 73 stations were sampled from 26 June to 12 September by the chartered longline vessel Ocean Prowler.

Sablefish relative population numbers (RPN) for the upper continental slope increased 5% from 1990-91. The RPN increase was significant only in the
Southeastern area. Some unknown fraction of the increase probably is due to a relatively strong year class recruiting through Shelikof Trough and onto the upper continental slope. Further, the length composition for sablefish shifted upward from 1990-91, indicating growth in length within the population and no significant recruitment. There is no evidence for any other strong year classes.

(Michael Sigler (907)789-6037 and Skip Zenger (206)526-4158)

Population Experiment in Chatham Strait

ABL and ADF&G conducted a cooperative sablefish population experiment in Chatham Strait, southeastern Alaska, during the period July-October 1991. Objectives of the study were twofold: 1) estimate the population size of sablefish in a study area within Chatham Strait; and 2) estimate the catchability coefficient (q) of sablefish caught on the longline gear used. The second objective was ABL’s main interest in the study; if successful, the catchability coefficient would be applied to the domestic longline survey, and an estimate of sablefish biomass would be computed for the Gulf of Alaska based on the survey’s CPUE. The experiment was a follow-up to a similar study conducted in 1989 that used the NOAA RV Townsend Cromwell. The 1991 study used the NOAA RV John N. Cobb to fish trawl and longline gear for four cruises, two before the September commercial sablefish fishery in Chatham Strait, and two after the fishery. The experiment attempted to estimate sablefish population in the study area using two methods: a mark-recapture experiment, in which sablefish were tagged before the fishery and then recovered from fishermen during the fishery; and a Leslie-Delury depletion experiment, based upon the John N. Cobb’s CPUE before and after the fishery. Results of the study showed trawl and longline catch rates declined 26.8% and 18.3%, respectively, after the fishery. Neither decline, however, was statistically significant because of the large variability in catch rates between hauls. Consequently, the CPUE data could not be used to compute a population estimate or a catchability coefficient. The mark-recapture data will be analyzed by ADF&G at a later date.

An ancillary objective of the study was to compare the survival of sablefish caught in trawls vs. longlines. Sablefish were randomly selected from various hauls of each gear type and transported live back to ABL, where they were retained in a large tank for 28-50 days. The overall survival rate of longline-caught fish was 98%, whereas only 52% of the trawl-caught fish survived. The trawl-caught fish, however, showed a wide variation in survival from haul to haul. Abrasion in the net appeared to be the major factor affecting survival of the trawl-caught fish. In hauls with much abrasive material such as sea urchins and shell debris, many of the sablefish were badly de-scaled and did not survive; in contrast, sablefish from hauls with little abrasive material appeared in good physical condition, and survival rates were up to 100%.

(David Clausen (907)789-6049)

Hook Competition Model

A stochastic model was developed which provides estimates of fish abundance from longline surveys. The model accounts for hook competition and is based on a binomial-Poisson mixture distribution. Fish are assumed to arrive randomly at the gear at some rate lambda, proportional to abundance (Poisson process). The probability of successive captures p, is assumed to be related to the number of fish already caught x (binomial process). The parameters lambda and p, are estimated from interarrival time data collected using hook timers during August 1991 for sablefish, Pacific halibut, and
Pacific cod in the Gulf of Alaska. The estimated parameters will be applied to a time series of longline survey data for sablefish to correct the abundance estimates for the effect of competition for hooks.

(Michael Sigler (907) 789-6037)

Sablefish Tag Recovery Program

Since 1983, ABL has tagged and released adult and juvenile sablefish for migration, population, and age studies in the eastern Gulf of Alaska. Tag releases currently total ~88,500, and recovered tags total 3,747, of which 2,728 have valid recovery information. Additionally, ~500 recoveries from 1991 are presently being processed. Two factors have helped increase the number and quality of tag returns in 1990 and 1991: the new sablefish capture reward to fishermen who return tags, and an increase in observer coverage aboard commercial fishing vessels.

A total of ~66,500 adult sablefish have been tagged and released by ABL. Of these, ~35,000 have been released in Chatham Strait during the course of various experimental studies since 1983. A total of 1,525 of the Chatham releases have been recovered, and 83% of these have remained in Chatham Strait, despite a mean time at large of 541 days. Apparently, most sablefish in Chatham Strait tend to remain there, and outmigration may be relatively low. More detailed analysis is in progress.

Approximately 22,000 of the ABL tag releases have been juvenile sablefish (ages 0+, 1+, or 2+) tagged in southeastern Alaska. Most of these fish (74%) were released over several year's time in one small bay, St. John Baptist Bay, located near Sitka, Alaska. This bay has been the only locality in southeastern Alaska where juvenile sablefish have been found consistently from year to year. Fish tagged as juveniles and recovered as adults in the commercial fishery now total 166. The recoveries are distributed as follows: Vancouver and Charlotte, 2.4%; Southeastern outside waters, 28.5%; Southeastern inside waters, 20.9%; Yakutat, 17.9%; Kodiak, 17.3%; Chirikof, 3.1%; Shumagin, 4.9%; and Bering Sea, 4.9%. Thus, these initial recoveries show a tendency for juvenile sablefish to migrate westward in the Gulf of Alaska.

(Ellen Varosi (907) 789-6059 or Tom Rutecki (907) 789-6051)

Sablefish Age Validation Based on Fish Tagged as Juveniles

ABL has begun a sablefish age validation study in cooperation with the AFSC's REFM Division. The study is based upon collecting otoliths from tagged adults that were originally released by ABL as juveniles. These tagged adults are of known age and can be used to validate the ages determined from the otoliths. So far, otoliths from 10 fish tagged as juveniles have been recovered. In 1992, observers aboard commercial fishing vessels in Alaska have been instructed to collect otoliths from all sablefish caught that have ABL tags, in an effort to increase the sample size for this study.

(Ellen Varosi (907) 789-6059)

West Coast

Sablefish Abundance Indexing

Sablefish relative abundance off Washington, Oregon, and California has been monitored since 1979 using standardized catch per unit effort (CPUE) from trap sets. In 1991, nine index sites off southern Oregon and California were sampled. Strings of 10 conical traps each were fished twice at each of five standard depths (225, 300, 375, 450, and 525 fm) and additional sets were made at non-standard depths of 150 fm (all sites) and between 630 and 850 fm (7 sites). Sablefish catch rates were highest at the three southern sites,
Cortes Bank, Carmel Bay, and Morro Bay) and lowest at Pt. Arena, Half Moon Bay, Pt. Delgada, and Cape Mendocino. Catch rates were highest at the 225 fm depth.

Catch rates declined notably from previous surveys in this area, which were conducted in 1984, 1986, and 1988. When averaged over all sites and depths, the mean number of fish caught per trap in 1991 was 67% lower than in 1988, 22% lower than 1986, and 64% lower than in 1984. Sablefish were larger on average in 1991 at all except the northernmost and the two southernmost sites. Overall mean length of sablefish caught increased almost 1 cm from 50.8 cm in 1988 to 51.7 cm in 1991, indicating a corresponding increase in mean weight from 2.71 lb to 3.06 lb.

(Norman Parks (206) 526-4119 or Frank Shaw 526-4120)

Age Validation

AFSC and SWFSC (Tiburon Lab) cooperated to develop an age validation study of sablefish. The study utilizes the method of injecting fish with oxytetracycline (OTC), which produces a mark on the otolith during tagging which can be detected when the fish is recaptured. On both 1991 surveys we tagged and released sablefish marked with oxytetracycline (OTC) to validate age determination techniques. During the trap survey, over 2,570 sablefish were released marked with special blue spaghetti tags. Only 83 sablefish were tagged, injected and released during the continental slope trawl survey. Three quarters of the released sablefish were injected with OTC and the remaining fish will serve as a control group to detect any mortality associated with the injections.

(Norman Parks (206) 526-4119 or Frank Shaw 526-4120)

Relating Flesh Condition to Biology and Environment

During the RACE trap and continental slope trawl surveys, sablefish color and flesh firmness were graded and recorded for all fish sacrificed for age structures. These data will be used to attempt to correlate the occurrence of soft, dark fish with environmental and biological factors such as depth of capture, size, sex, and age.

(Norman Parks (206) 526-4119 or Frank Shaw 526-4120)

b. Assessment

Bering Sea and Gulf of Alaska

Sablefish of the Gulf of Alaska, Bering Sea and Aleutians are considered one large stock. Therefore, to alleviate some of the departures from a closed population assumption that occur in separate analyses, these three regions are combined into one analysis for stock assessment. Historic biomass estimates as determined by stock reduction analysis showed a declining stock trend through 1978. During these years the stock was heavily exploited by foreign fisheries. Estimates of exploitable biomass after 1979 were determined by scaling relative biomass indices from an annual longline survey to estimates of absolute biomass, based on comparisons of longline and bottom trawl survey catch rates. Stock abundance increased after 1980 peaking in 1985 at nearly 400,000 t. Lower exploitation rates and a strong 1977 year class, which recruited in 1982, led to this improved stock condition. After 1986, the stock has been fairly stable but showing a slight decline. Although the stock is declining there is no evidence that it is being overfished. The decline is attributed to the lack of significant recruitment in recent years. The stock is at a high level and considered to be in good condition. The projected 1992 estimate of exploitable biomass (assuming zero recruitment) for the Bering Sea/Aleutian Islands region is 37,400 t, and 179,000 t for the Gulf of Alaska.
Sablefish are fully utilized and are harvested under an $F_{0\text{th}}$ strategy. The 1992 Acceptable Biological Catches are 1,400 t for the Bering Sea, 3,000 t for the Aleutians, and 20,800 t for the Gulf of Alaska.

The sablefish population of the Gulf of Alaska is still at a relatively healthy level, but with no strong recruitment evident in recent years, the population has been decreasing. Exploitable biomass for the beginning of 1992 for outside waters as estimated from the NMFS trawl and longline surveys is 179,000 mt, down from 194,000 mt in 1991 (248,100 mt in BS, AI and GOA combined).

Yield estimates are determined from stock reduction analysis modified to explicitly track estimates of exploitable biomass and provide an estimate of recruitment. To alleviate some of the departures from the assumption of a closed population, the Gulf of Alaska, Bering Sea, and Aleutian Islands regions have been combined and analyzed as one stock since 1989. The recommended yield is then apportioned according to estimates of current biomass. The recommended acceptable biological catch (ABC) for the Gulf of Alaska was 26,200 mt in 1990, 22,500 mt in 1991, and 20,800 mt in 1992. The ABC's are computed by multiplying the $F_{0\text{th}}$ exploitation rate (0.116) by the estimate of exploitable biomass at the beginning of the fishing year.

NMFS conducts two longline surveys to track abundance trends in the Gulf of Alaska: the domestic survey and the Japan-U.S. Cooperative Survey. In 1990, results of the two surveys diverged significantly from each other, and the difference between the two surveys continued in 1991. Studies are now in progress by the AFSC's RACE Division to determine the reason for the difference in results. In computing the 1992 ABC's, an average of the two surveys was used to project the exploitable biomass estimate.

(Sandra Lowe (206) 526-4230 or Jeff Fujioka (907) 789-6026)

**Age-structured Population Model**

Sablefish annual recruitment and biomass in the Gulf of Alaska were estimated with an age structured population model via the "stock synthesis" approach. Because no time series of age compositions was available to directly measure recruitment, recruitment was estimated indirectly from length compositions from the Japan-U.S. cooperative longline survey and a length-age relationship. Relative biomass was measured by the Japan-U.S. cooperative longline survey from 1979-90 and the domestic longline survey from 1988-90; absolute biomass was measured by the triennial trawl survey in 1984, 1987, and 1990. Absolute biomass and recruitment from 1976-90 were estimated in this study.

(Michael Sigler at (907) 789-6037)

**West Coast**

The landed catch of sablefish in 1991 was 9,451 mt. This exceeded the ABC of 8,900 mt primarily because of inaccuracy in projecting the rapid rate of catch by the fixed gear fleet. In 1991 the fixed gear open season lasted from April 1 only until May 23. No new assessment was conducted in 1991, primarily because of the discovery of a problem in expanding port sample data to fishery catch-at-age. The west coast sablefish stock was assessed in 1990 through application of the synthesis model to fishery size and age composition data from 1986-1989 and trawl and pot survey data. The assessment was split into northern (U.S.-Vancouver and Columbia INPFC areas) and southern areas on the basis of known low rates of mixing of adult sablefish, and increased evidence of slower growth among fish captured off southern and central California. The trawl survey biomass estimates from southern Oregon played an important role in the northern area assessment because the survey area constitutes a significant fraction of the northern assessment area and a survey in 1989 replicated abundance levels observed in 1984 and 1988. The recommended assessment results that match this biomass level do not, however, provide a good match to the decline in the pot
survey's estimate of sablefish abundance. The northern area's assessment indicates that the biomass of age 3+ sablefish was about 80,400 mt at the beginning of 1990 and the biomass of mature females was 36,100 mt. This level of spawning biomass is intermediate between 38,800 mt (35% of virgin spawning biomass) and 31,800 mt (spawning biomass that produces MSY under previously assumed level of recruitment density-dependence), so this area's stock is judged to be approximately at its optimum level. Application of the F_{MS} exploitation policy to the expected 1991 biomass produces a recommended landed yield of 4,130 mt for the northern area. The assessment in the southern area has greater uncertainty because of the lesser amount of survey data. The recommended assessment indicates that the biomass of age 3+ fish at the beginning of 1990 was 87,600 mt and the biomass of mature females was 45,200 mt. This level of spawning biomass is above 39,300 mt (35% of virgin spawning biomass) and 33,400 mt (spawning biomass that produces MSY under previously assumed level of recruitment density-dependence). Application of the F_{MS} exploitation policy to the expected 1991 biomass produces a recommended landed yield of 4,730 mt for the southern area. Research efforts were also directed at exploring depth and latitude patterns in the age-specific distribution of sablefish.

Richard Methot at (206) 526-6525

6. Flatfish (Dover, English, arrowtooth, petrale)
   b. Assessment

Bering Sea

The abundance of most of the species of flatfish in the eastern Bering Sea have shown substantial increases during the 1970s and 1980s, and many are currently at observed peak levels of abundance. Yellowfin sole, which suffered a severe decline in abundance from overfishing in the early 1960s, is the second most abundant species in this region after walleye pollock. The total harvest of yellowfin sole in the eastern Bering Sea in 1991 was 84,482 t, well below the 1991 TAC of 135,000 t. This underharvest is due to the prohibited species (halibut, king and tanner crab) catch limits being attained well before the target quota can be reached. The fishery harvests a wide range of age classes beginning at age 6 with yellowfin sole not being fully recruited until age 13. The stock remains at high abundance levels after rebuilding during the late 1970s and early 1980s from a series of stronger than average year classes spawned from 1968-77. In the 1991 assessment, fishery catch-at-age information was used in cohort analysis and the stock synthesis model to discern the age-structured population abundance, believed to be at more than 2.6 million t. Fishing mortality values were developed from a yield per recruit model to evaluate potential harvesting strategies. For 1992 a F_{0} value of 0.14 was used to develop an ABC of 372,000 t with the TAC set at 235,000 t.

Rock sole catches from the eastern Bering Sea in 1991 was 26,297 t, primarily from a valuable roe fishery conducted northward of the Alaska Peninsula during the winter spawning period. Harvest levels remained well below the 1991 TAC of 90,000 t. Biomass estimates from the 1991 demersal trawl survey indicate the population abundance is at 1.59 million t, continuing the trend of biomass increase seen during the 1980s. Survey age composition from the 1990 survey indicates that 88% of the rock sole population numbers are ages 3-7, corresponding to the 1983-87 year classes. Analysis of life history parameters from a dynamic pool model provide fishing mortality values at F_{moy} (F=0.176) and F_{0} (F=0.159) to explore possible harvest strategies. An ABC of 260,800 t (TAC is 40,000 t) was developed for 1991 based on the F_{0} exploitation rate.

Survey data have indicated that the other two principal species of small shelf flatfish in the eastern Bering Sea were also at observed high levels of abundance in 1991. The estimates were 570,300 t for flathead sole, and 529,100 t for Alaska plaice. The abundance of these species remains high, and recruitment continues to be strong for flathead sole. These two species are
managed as a complex with a combined ABC of 199,600 t for 1992 and a TAC of 79,000 t. The combined 1991 catch was well below the quota at 30,400 t.

The conditions of the two principal species of large flatfish in the eastern Bering Sea, arrowtooth flounder and Greenland turbot, differ. Based on survey estimates, the exploitable abundance of arrowtooth flounder has increased from less than 100,000 t in 1982 to 461,600 t in 1991. Over this same period, recruitment of Greenland turbot has been very low and the presence of juvenile fish reported from the Bering Sea shelf and slope has been notably reduced. Assessments of the adult population, which occupy continental slope waters, is limited to triennial surveys such as in 1991, but these surveys incompletely sample this portion of the population. Because of the poor recruitment that has been observed since the early 1980s, exploitation of the adult population has been restricted and the TAC has been set at 7,000 t. Arrowtooth flounder remain lightly exploited with the 1991 catch of 4,100 t taken primarily in the pursuit of other species. For 1992 the ABC and TAC of arrowtooth flounder is set at 82,300 t and 10,000 t, respectively.

Gulf of Alaska

Management of the Gulf of Alaska flatfish resource has been divided into four categories by the North Pacific Fishery Management Council for 1991. These categories include: "shallow water flatfish", "deep water flatfish", arrowtooth flounder, and flathead 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. Arrowtooth flounder, because of its present high abundance and perceived low commercial value, was 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.

Due to halibut bycatch in commercial trawl fisheries, the total catch of Gulf of Alaska flatfish species was 31,500 t in 1991, well below the combined TAC of 57,000 t. Biomass estimates from the 1990 Gulf of Alaska trawl survey indicates the total flatfish resource continues to increase with some species declining (rex and rock sole), some increasing (flathead sole and arrowtooth flounder) and some remaining stable (yellowfin sole). Trawl survey size compositions indicate the continued presence of juvenile fish recruiting to the stock for most species. Although the flatfish species are generally thought to be near or above virgin levels, they are managed under the F 0 _1 approach since this strategy may represents a fishery which maintains a larger spawning stock and mean size.

(Thomas Wilderbuer (206) 526-4224)

West Coast

Pacific Halibut

The RACE West Coast groundfish subtask collaborated with the IPHC in an investigation comparing results of the 1977-1989 triennial trawl surveys with IPHC stock assessments based on catch-at-age data and commercial longline catch per effort in Area 2A (roughly from 43°N lat. to the US-Canada border). The surveys clearly show a dramatic increase in apparent total abundance in this area from 1980 to 1986 and 1989, coupled with a southward expansion of the range of halibut catches (as far south as San Francisco in 1989) and an increase in the frequency of their occurrence (from less than 20 fish in 1977 and 1980 to more than half of the Area 2A stations in 1989). In contrast to this order of magnitude increase in apparent abundance from survey results, commercial longline catch rates, used as an index of exploitable biomass in the IPHC stock assessments, remained flat through the late 1970s and mid 1980s. In the late 1980s, the commercial CPUE increased dramatically, while the survey estimate remained steady.
The IPHC assessment uses the CAGEAN model to estimate exploitable (age 8+) biomass, while the surveys estimate total available biomass. CAGEAN has provided estimates of exploitable halibut in Area 2A of about 125,000 fish (1.5-1.7 million lb net) while the 1989 survey estimated 466,000 fish (5.5 million lb net), including fish younger than 8 yr that are available to the survey trawl. Comparisons are hampered by the lack of age data from the survey samples, a situation that will be rectified during the 1992 triennial survey. Meanwhile, a correction was applied to the survey estimate, truncating the biomass at lengths corresponding to age 8+ fish (72 and 84 cm were used) resulting in an estimate of between 145,000 and 329,000 fish. Possible reasons for the discrepancy in the results include CAGEAN systematically underestimating abundance (an underestimate of M), the survey systematically overestimating (due to herding, etc.), or differential availability of components of the population to longline and trawl gear.

(Mark Wilkins (206) 526-4104)

Dover Sole

Size and age composition data from the INPFC Eureka area were analyzed by stock synthesis, a separable catch-at-age model. In this assessment recruitments are estimated by the model instead of the assumption of constant recruitment used in 1990. In the Eureka area the 1990 survey biomass estimate was used to determine plausible levels of 1990 biomass. The incorporation of the survey resulted in lower levels of biomass being more plausible than indicated in the 1990 assessment. Sharp increases in the percentage of small Dover sole in the fishery occurred beginning in 1983-84. The model accommodated this change by having separate availability and retention patterns for the periods 1971-82 and 1983-present. The change in selectivity of larger fish was modeled as a function of the increase in depth of the catch.

Two plausible levels of virgin recruitment are identified, resulting in an approximately two-fold range in estimated current biomass, and a survey ratio of 0.38 to 0.83 (where 1.0 indicates the 1990 biomass available to the survey is equal to the estimated survey biomass). In the Eureka area, recent landed catches have declined to about 3,500 t. MSY, estimated under an assumed level of density-dependent recruitment, is in the range 3,000-4,1000 t. The current female spawning biomass is estimated to be slightly below the target level for the lower biomass scenario and above the target level for the higher biomass scenario. The recommended yield is calculated by applying F_{35} (fishing mortality that reduces female spawning biomass per recruit to 35% of its unfished level) to the exploitable biomass. This results in yields for 1992 in the range 3,071-6,815 t.

(Jack Turnock at (206) 526-6549)

7. Pacific whiting

b. Assessment

The U.S. and Canadian harvest of Pacific whiting in 1990 was 260,000 metric tons (t). In 1991, the yield increased by 22% to 316,000 t. The catch of Pacific whiting in the U.S. zone in 1990 was dominated by the 1980, 1984, and 1987 year classes. These year classes accounted for 24%, 42%, and 26% of the U.S. catch respectively. In the 1991 assessment, the stock synthesis model was used to estimate age-structured population abundance, past levels of female spawning biomass, and recruitment for the 1959-88 year classes. The stock synthesis model estimated the age 2+ biomass at the start of 1991 at 2.056 billion t. Biomass has declined monotonically from a maximum of 3.185 billion t in 1986. The age-2 recruitment estimate of the 1987 year class was 1.903 billion fish, larger than the 1960-89 mean recruitment of 1.230 billion fish, while a recruitment of 0.603 billion was estimated for the 1988 year class. An age-structured model was used to forecast yields for 1992-94. Several harvesting
strategies are presented: a constant F strategy, a variable F strategy, where fishing mortality for a particular year is proportional to the level of female spawning biomass, and a hybrid strategy that combines features of the other two policies. Three harvest rates are presented for each harvest strategy. These harvest rates are determined by probability that female spawning biomass will fall below a cautionary level of 457,000 t in long-term simulations of the Pacific whiting population. When a hybrid fishing strategy is applied to the projected numbers at age in 1992, the potential total yield is calculated to be 160,000 t at low harvest rate, 232,000 t at a moderate harvest rate, and 288,000 t at a high harvest rate. If recruitment remains near the 1960-89 median recruitment of 0.678 billion fish, the outlook for the immediate future is for a continuing decline in annual yield. The recruitment of a strong year class to the fishery would substantially increase the projected yields.

Significant 1991 research efforts were directed towards improved understanding of the migratory pattern for Pacific whiting, especially as it influences recommendations for U.S.-Canada harvest allocation, and display of patterns of salmon and rockfish by-catch in the Pacific whiting fishery.

(Martin Dorn at (206) 526-6548)

10. Other

Walleye pollock

a. Research

Bering Sea

Hydroacoustic Assessment of Walleye Pollock on the Bering Sea Shelf

The fifth triennial survey of walleye pollock on the Bering Sea shelf was completed during June 22 - August 31. Operations were conducted within depths of about 30 to 250 fm. and progressed in a northwesterly direction from 162 degrees W longitude to the US-USSR convention line. The total midwater biomass of pollock as assessed using the hydroacoustic system appears to be a little less than half of that encountered during the 1988 survey. Two year old pollock (1989 year class) were fairly abundant in large midwater schools over much of the area West of the Pribilof Islands and contributed perhaps 25-30 percent to the total biomass estimate. The remaining portion of the pollock biomass was found in near bottom layers generally ranging no more than 10-15 m from bottom. The apparent decrease in total biomass since 1988 may not be as drastic as it first appears. The population of the two year old fish was large, but individual weights were small. They will contribute a significant biomass by the time they grow large enough to enter the exploitable portion of the population.

Gulf of Alaska

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. Areas of research include field studies of eggs and larvae in relation to zooplankton and the physical environment, biochemical methods for assessing larval starvation and predation, and pollock behavior. FOCI conducted four cruises aboard the NOAA ship Miller Freeman during the spring of 1991 in the Shelikof Strait region of the Gulf of Alaska to study the effects of the environment on the eggs and larvae of walleye pollock. The unusually stormy periods of 1991 will provide a unique opportunity to study the
effects of extreme environmental conditions as we analyze larval distribution and abundance. Satellite drifters indicated a higher probability that larvae would be swept off the shelf. At-sea counts of larvae caught in bongo nets over the shelf and sea valley indicated that larvae were not abundant in 1991 relative to 1988-90. During the last cruise of 1991, pollock larvae were absent from catches at 51 of 97 stations. This compares unfavorably to the last spring cruise of 1990 when pollock larvae were absent from only 2 of 96 stations. Since high concentrations of larvae were not found, improvised field work in 1991 concentrated on the process of offshore advection of larvae. A second noteworthy observation was that many of the larval pollock which were captured in the Strait had a large portion of their guts filled with phytoplankton rather than copepod nauplii as in other years.

Laboratory studies on reared pollock larvae were conducted to (1) calibrate biochemical indices; (2) estimate feeding, digestion, and gastric evacuation rates; (3) calibrate histopathological condition indices; and (4) determine larval shrinkage caused by handling and preservation. 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. Experiments were also conducted at the University of Washington's Friday Harbor Laboratory. As in previous years, the Sand Point larvae were raised in Elliot Bay sea water and fed on a diet of rotifers. At the Friday Harbor Laboratory the larvae were raised in higher quality sea water and fed on a local source of copepods (the main prey eaten by wild larval pollock).

Growth and condition of larvae cultured at both facilities will be compared. Larvae were fed various prey types and at different concentrations in several container sizes and sampled to determine the relative value of various prey to their growth and survival.

Laboratory studies on environmental factors which influence the distribution and survival of walleye pollock eggs, larvae, and juveniles are continuing at the Center's experimental facilities at the Mark O. Hatfield Marine Science Center in Newport, Oregon. Experiments have shown that egg density and, therefore, vertical distribution may be influenced by light conditions. Eggs developing under constant darkness showed densities and distributional trends similar to those observed at 150-200 m in the Gulf of Alaska, while those held under constant light increased in density and thereby exhibited a mechanism for avoiding light.

Behavioral studies on walleye pollock juveniles showed that the interaction of factors such as light, temperature, food, and predators play an important role in determining vertical distribution. Social interactions among juveniles relative to food dispersion have also been shown to affect distribution. Juveniles feeding upon food which is distributed in patches are responsive to the behavior of other individuals and utilize shared information to locate food. Such social interaction results in a more cohesive aggregation than juveniles feeding on more uniformly distributed food where social interactions are minimal. The result of these interactive differences is that a similar number of fish could occupy markedly different spatial limits and thereby influence attempts at assessing population size. Juveniles have also been shown to possess the capability to use seagrass as a refuge from predators. The use of seagrass as a refuge from predators appears to be ontogenetic with larger 0-age juveniles having less affinity for this type of refuge as they move into deeper water.

Hydroacoustic Assessment of Walleye Pollock in the Gulf of Alaska

Walleye pollock abundance was surveyed in the Gulf of Alaska during March 16-27. A small area was surveyed just to the South of Sanak Island where commercial quantities of pollock were reported during a previous fishing season. Only one small school of moderate density, composed of large, old fish was encountered in the area. Two survey passes were made through Shelikof Strait and consisted of approximately parallel transects across the strait, starting and terminating at the 50 fm. depth contours. The first series progressed from S to N, from near Cherikof Island to mid Afognak Island. The second series progressed
from N to S and covered approximately the upper half of the strait. The most abundant year class of pollock found in the strait was three years old (1988 YC). The total estimated biomass was similar to that encountered during 1990. The abundance of pollock in Shelikof Strait appears to be increasing from year to year, but at a very slow rate. Nearly half of the spawning population was composed of fish in excess of 48-50 cm length.

b. Assessment

Bering Sea and Aleutian Islands

Pollock abundance in the eastern Bering Sea was estimated with two age-structured methods, cohort analysis and CAGEAN, with data up to and including the 1990 catch-at-age and the 1979-88 triennial combined hydroacoustic and bottom trawl survey. Age 1 indices from the 1990 and 1991 trawl surveys were used to forecast age 3 recruitment in 1992 and 1993. Cohort analysis indicates a minor decrease in abundance while the CAGEAN results indicate a sharp drop in biomass since the peak value in 1985. The confidence interval around the 1990 CAGEAN estimate overlaps the confidence interval from the trawl survey but does not contain the point estimate from cohort analysis or the trawl survey. The cohort analysis biomass estimates were chosen over CAGEAN because they track the survey biomass trend in recent years better and also because cohort analysis uses more age-specific information from the surveys than does CAGEAN.

Current abundance is above B_{msy} (6 million t). The strong 1982 and 1984 year-classes now contribute substantially to the fishery. Recruitment of age-three pollock is projected to be below average in 1992 but above average in 1993. The ABC for this stock was computed with an exploitation rate corresponding to F_0.31 = 0.31 which is close to F_{msy} = 0.33 obtained by Quinn and Collie. Application of this fishing mortality rate gives a 1992 eastern Bering Sea ABC of 1,490,000 t. The ABC is less than in 1991 because 1992 projected biomass is lower than the value projected for 1991 in 1990. Exploitation at the F_0.31 rate when abundance is greater than B_{msy} does not violate the Council's overfishing definition.

The Aleutian Islands pollock stock was surveyed by bottom trawl in the summer of 1991, and an on-bottom exploitable biomass of 180,000 t was estimated. The 1992 Aleutian Islands exploitable biomass was calculated with the following assumptions: 1) The on-bottom component of the pollock stock in the Aleutian Islands area is the same as in the eastern Bering Sea (79%), the total exploitable biomass is 228,000 t. 2) The biomass trend in the eastern Bering Sea from cohort analysis is similar to the Aleutian Islands so that the 1992 Aleutian Islands biomass can be projected. The pollock biomass for 1992 should decrease to 215,000 t.

Pollock taken near Bogoslof Island have a consistently different age composition and slower growth rates compared with the eastern Bering Sea stock. A hydroacoustic survey in the winter of 1991 estimated the abundance of Bogoslof pollock to be 0.6 million t. Recruitment to this area has been very low in recent years. Assuming that fishery removals during 1991 were matched by growth and recruitment, the 1991 estimate can be projected forward by applying an instantaneous natural mortality rate of 0.3, giving a 1992 exploitable biomass of 444,000. Applying a catch-to-biomass ratio of 0.24 results in a 1992 ABC of 107,000 t for the Bogoslof fishery. However, it is likely that these pollock are also caught outside the U.S. EEZ and that the entire Bogoslof ABC may be caught in international waters, in which case the Bogoslof TAC should be zero. Therefore the Bogoslof ABC is not added to the eastern Bering Sea ABC for the purpose of determining the Bering Sea pollock TAC.

Large catches continue to be removed from the international zone of the Aleutian Basin (donut hole). The 1987, 1988, and 1989 catches all exceeded the catch from the U.S. EEZ. Data collected to date suggest that donut hole pollock are related through spawning and recruitment to pollock on the surrounding continental shelves. Future ABCs in the U.S. EEZ may need to be adjusted for catches taken elsewhere.

(Dr. Vidar Wespestad, (206) 526-4249)
Estimates of the exploitable biomass of walleye pollock (Theragra chalcogramma) are 1,050,000 t in 1990 and 1,088,000 t in 1991 as determined from the stock synthesis (SS) model. The estimated 1992 biomass is 838,000 t, which is based on a projection of the 1991 biomass estimate from stock synthesis.

The current assessment incorporates two important changes relative to 1990. First, the 1984, 1987, and 1990 gulfwide bottom trawl survey biomass estimates were revised. This was due to changes in the fishing power correction factors applied to bottom trawl survey data. Second, historical estimates of discard from the domestic fishery (1986-present) were accounted for in the SS model.

In addition, several sources of information have been updated since the last assessment. 1) biomass estimates from the 1991 hydroacoustic survey; 2) estimates of catch-at-age from the 1991 spring fishery; 3) annual estimates of weight-at-age from the hydroacoustic survey; 4) revised estimates of maturity at age; 5) updated estimates of discard and catch; 6) historical length frequency data; and 7) estimates of biomass for the Chirikof area in 1975 that was expanded to provide a gulfwide estimate.

The addition of the varied pieces of new information required that several configurations of the model be explored. The relative impact of several factors were examined including: a) utilization of a composite model (all data components weighted equally); b) imposing 1, 2, or 3 fishery partitions; c) incorporation of historical length-frequency data or the estimated age composition data; and d) estimation of selectivity vectors for the surveys.

The 1991 hydroacoustic data continue to confirm that the 1988 year class will be above average. The fishery catch-at-age data for both 1990 and the spring of 1991 are dominated by the strong 1984 year class. In addition, the spring 1991 fishery age data showed a dominant 1982 year class which had previously not shown up in any other data set. This may be attributed to aging error. Exploratory runs with SS were not able to provide a reasonable fit to the 1991 fishery age composition. Because these data may not represent catch at age for the entire year, it was not included in subsequent runs.

Based on the exploratory runs, the following determinations are made: a) a priori assumptions regarding the information content of survey data are necessary, and b) 3 partitions of the fisheries data and the exclusion of the preliminary 1991 fisheries age composition data are justified. With these considerations, three configurations of the stock assessment model were then produced. All three versions incorporated hydroacoustic data as indices of abundance and the only absolute biomass estimate was from the 1990 bottom trawl survey. Previously, the model was tuned to either the hydroacoustic biomass estimate or the bottom trawl survey biomass estimate, as these pieces of information were contradictory and could not be simultaneously fit in the model. Recent estimates of biomass from the hydroacoustic surveys have been much lower than gulf wide bottom trawl estimates. Weighting the hydroacoustic time series equally to the fisheries data provides a mechanism for accounting for the large population estimates observed in Shelikof Strait during the early 1980s. Tuning to the 1990 bottom trawl biomass estimate adjusts the ending biomass to a level that was observed in the recent gulfwide bottom trawl survey.

The three configurations of the model with survey data incorporated as above, differed as follows: Model A did not incorporate the estimate of 1975 biomass and let the model estimate survey selectivity; Model B incorporated the 1975 biomass estimate and also let the model estimate survey selectivity; Model C incorporated the 1975 biomass estimate, but survey selectivity was fixed. The first two models (A and B) showed a linearly declining selectivity with increasing age for the hydroacoustic survey. This selectivity did not seem the appropriately represent what would be the expected selectivity for the hydroacoustic survey.

Predicted 1991 mid-year biomass was 843,000 t. A Beverton-Holt stock recruitment relationship was fit to the estimated recruitments and spawning stock biomass which produced an F_m of 0.16. Harvesting at this level for 1992-94 (assuming weak recruitments during this period) would provide an average yield.
of 108,000 t. Current biomass is predicted to be above the B_{max} level. The ABC for 1992 is set at 99,400 t and the TAC at 87,400 t.

(Dr. Anne Hollowed (206) 526-4223)

D. Other related studies

Behavior Observations to Facilitate Bycatch Reduction

In a joint project with industry and the International Pacific Halibut Commission, the Conservation Engineering Task of the RACE Division has been developing techniques to observe fish behavior in trawls to facilitate the development of more selective fishing gear. The goal of this project is the reduction of halibut bycatch in the trawl fisheries in the Gulf of Alaska and Bering Sea.

A remotely operated underwater video system has been developed which has been mounted on trawls to observe fish behavior in response to different components and modifications of the trawl. It consists of an ultra low light video camera mounted on a pan-tilt apparatus in a protective cage. A telemetry cable to the towing vessel allows real time viewing and control.

Observations made to date have proven the usefulness of the system for this type of observation. Behavioral comparisons made include:

1. The location and endurance of several fish species swimming in front of the trawl's footrope. Large halibut moved over a much wider area than small flatfish, and remained in that area for much longer periods.

2. Large halibut and cod tended to lead up lines suspended over the belly of the trawl, while small flatfish dove through them and moved along the net panel itself.

3. In swimming back through the intermediate section of the trawl, small flatfish were mostly close to the bottom panel, while larger halibut and cod were seen more often in the middle and top areas.

4. Halibut did not use escape holes sized to their body proportions, even though these holes were located in a region of relatively still water, allowing ample opportunity for them to locate the holes.

This project is scheduled to continue this summer, testing a new set of trawl modifications. Improvements will include adding a trawl-mounted sector scanning sonar to observe fish in front of the trawl doors and between the doors and the trawl.

(Craig Rose (206) 526-4128)

Electronic Measuring Board

The NMFS surveys annually generate hundreds of thousands of groundfish length records. Fish lengths routinely are measured and recorded either by pencil markings on plastic ruler strips or by punching pin holes in plasticized paper strips. These methods are quick and efficient on deck, but suffer from several faults: the pin holes occasionally overlap and are hard to read, these holes must be tallied, pencil marks are often rubbed off, and the tallied length frequencies must be keypunched into an electronic database. Because of these faults, alternative methods of recording lengths have been explored and a promising new board was tested during the 1991 domestic longline survey in the Gulf of Alaska.
The length measuring board consists of a mylar ruler labeled with bar codes designating length and sex. In use, the fish is laid down on the board, and the appropriate bar code is read by a bar code wand. The information is stored in an electronic data logger attached to the bar code wand. The species and depth stratum are also recorded automatically when length and sex are recorded, but are reset only when they change. The advantage of this approach is that only a single stroke of the bar code wand is necessary to record all information for each fish. At the end of the day, the data in the electronic data logger is downloaded to personal computer files.

The board successfully survived twenty-one days at sea and recorded over 34,000 lengths. The reliability of the bar code scanner was checked routinely and found reliable. Battery power in the electronic data logger was sufficient for the eight to ten hour work day. The bar code wand and electronic data logger are sealed and almost entirely waterproof. The only connection exposed, that between the bar code reader and the data logger, was sealed with plastic. The main disadvantage of the electronic measuring board is that there is no hard copy of the data until the data are downloaded to the personal computer and printed. Thus, up to one day of length data could be lost if the data logger failed. However, the data logger worked reliably throughout the cruise. The rate of recording lengths for the electronic measuring board was similar to that for the paper and punch method. The electronic measuring board reduced the time necessary for shipboard data processing by about half. Furthermore, the disadvantages of the pencil or paper punch recording methods were avoided and the tedious process of tallying and keypunching length frequency data was no longer needed.

(Michael Sigler (907) 789-6037)

Socioeconomic Task - REFM

During 1991, the Socioeconomic Task was actively involved in providing economic information to the Pacific and North Pacific Fishery Management Councils, NMFS, other agencies, and the industry. This included preparing reports and publications, participating on Council plan teams, and preparing and reviewing research proposals and programs.

The major issues for which information was provided included the bycatch problem in the groundfish fisheries off Alaska, limited entry in the Alaska sablefish and halibut fisheries and in the West Coast groundfish fishery, and the allocation of Alaska and West Coast groundfish quotas between at-sea and on-shore processors.

Task members also contributed to the development of studies to evaluate economic effects of the Exxon Valdez oil spill in Prince William Sound, reviewed Sea Grant and Saltonstall-Kennedy proposals, assisted in NMFS efforts to readdress issues associated with the Marine Mammal Protection Act and Endangered species Act, and participated in drafting the North Pacific Fisheries Research Plan.

The reports and publications presented the results of research concerning fishery product exports from the Pacific Northwest and Alaska and the implications of the bycatch limits on groundfish fisheries. Task members also prepared a draft report that served as the economic component of the stock assessment and fishery evaluation for the Gulf of Alaska and Bering Sea/Aleutians Island groundfish fisheries.

(Dr. Joe Terry (206) 526-4253)
VIII. OTHER TOPICS FOR DISCUSSION

Codend Mesh Size/Shape Studies

Trawl mesh size studies recently completed at the University of Washington and partly funded by the AFSC suggest that changing the size and shape of the mesh in the codends of trawls could reduce fishing pressure on West Coast groundfisheries and probably would not reduce long-term yield. The studies included 102 trips aboard commercial trawlers testing codends constructed of various sizes (3"-5.5") of diamond- and square-shaped mesh during 1988-1990. The tests involved trawling on a variety of bottom types between 5 and 650 fm for rockfish, nearshore, and deepwater assemblages. Use of commercial vessels adds to the credibility of the results for actual fishing conditions and applicability for management.

Results of the field tests showed that larger-mesh codends let more young, small fish escape than did smaller-mesh codends. In addition, square-mesh codends allowed more juvenile roundfish (such as sablefish) to escape than did diamond-mesh codends of comparable size. The fish that escape may also suffer less physical stress and thus survive the escapement better, resulting in more abundant adult populations in later years. While changes in mesh size and shape won't solve all West Coast groundfisheries problems, this study suggests that judicious use of such regulations would reduce waste and could also permit relaxation of some trip limits in the short term. In the longer term, there is the potential for increases in annual quotas and reductions in the sensitivity of yields to fishing effort. Under some conditions, gain appears possible without pain. Field tests showed that larger square mesh brought in as much revenue as smaller diamond mesh in the deepwater assemblage fishery (Dover sole, sablefish, and thornyheads).

(Dr. Ellen Pikitch, UW School of Fisheries (206) 543-1513)


