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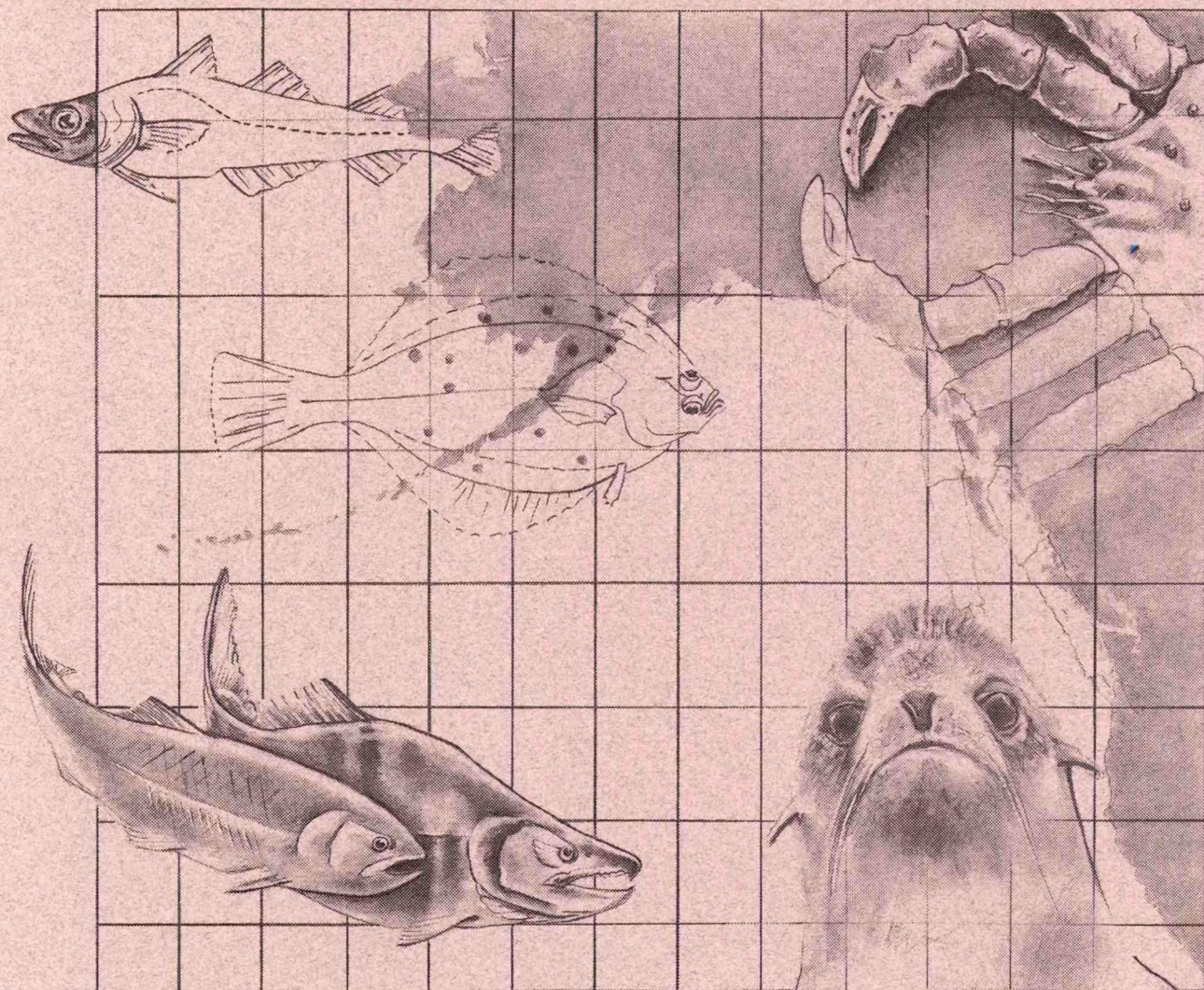


Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S. DEPARTMENT OF COMMERCE

Biennial Report for Calendar Years 1990-91



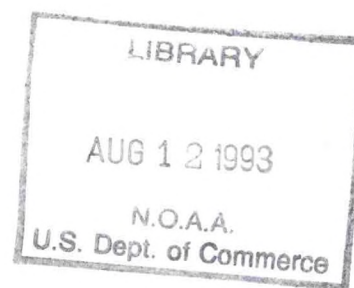
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ALASKA FISHERIES SCIENCE CENTER

Seattle, Washington

BIENNIAL REPORT

CALENDAR YEARS 1990-91



Compiled by

Publications Unit
Alaska Fisheries Science Center
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Alaska Fisheries Science Center)

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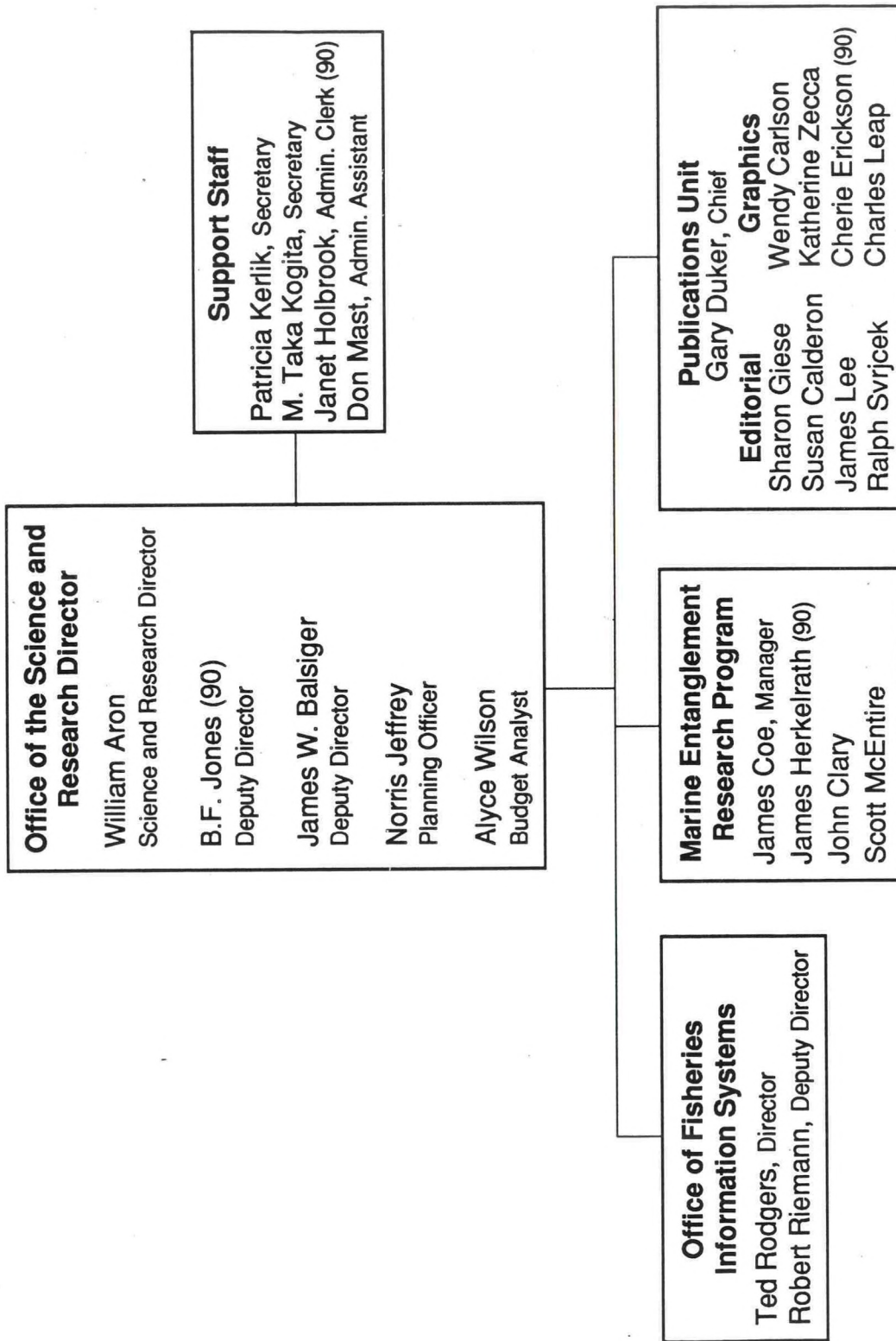
ALASKA FISHERIES SCIENCE CENTER

The Alaska Fisheries Science Center (AFSC) is the research branch of the National Oceanic and Atmospheric's National Marine Fisheries Service (NOAA-NMFS) responsible for fisheries research in the coastal waters of Alaska and the U.S. West Coast. This region includes over 50% of the U.S. coastline and over 70% of the U. S. continental shelf. These waters, including the North Pacific Ocean and the eastern Bering Sea, support some of the most important commercial fisheries in the world — Pacific salmon, walleye pollock, sablefish, Pacific cod, and king and Tanner crab — with a total biomass of more than 26 million metric tons. These waters are also the home of some of the world's largest populations of marine mammals and seabirds. Marine mammals of particular interest include the Steller sea lion, northern fur seal, Dall's porpoise, bowhead whale, humpback whale, gray whale, and beluga whale.

Passage of the Magnuson Fishery Conservation and Management Act and establishment of the 200-mile fishery conservation zone in 1976 (changed to Exclusive Economic Zone (EEZ) by Presidential Proclamation in 1983) gave new impetus to the AFSC to conduct research in support of conservation and management of the region's living marine resources. Center scientists study the life history of the region's living marine resources. They estimate the size and value of commercial fishery resources, monitor foreign and domestic fishing operations, provide information on protected species, and study the physical properties of freshwater, estuarine, and marine environments. Scientists also interact with their counterparts in Canada, Japan, the U.S.S.R. (Russia), Republic of Korea, Taiwan, China, and other nations to jointly preserve and conserve the region's living marine resources. The AFSC is made up of the Auke Bay Laboratory, the National Marine Mammal Laboratory, the Resource Assessment and Conservation Engineering Division, the Resource Ecology and Fisheries Management Division, and the Center Director's Office which includes the Marine Entanglement Research Program, Office of Fisheries Information Systems, and other support services. Program objectives are carried out at NOAA's Sand Point facilities, at the Auke Bay Laboratory in Alaska, and at smaller field stations at Little Port Walter and Kodiak, Alaska.

This biennial report describes some of the major research activities of the Alaska Fisheries Science Center.

CENTER DIRECTOR'S OFFICE ORGANIZATION CHART 1990-91



MARINE ENTANGLEMENT RESEARCH PROGRAM

During calendar years 1990 and 1991, projects funded by the NMFS's Marine Entanglement Research Program (MERP) addressed the issue of marine debris as required by the Marine Plastic Pollution Research and Control Act of 1987 (MPPRCA).

EDUCATION AND PUBLIC AWARENESS PROJECTS

The MPPRCA directs NMFS to provide education and public awareness programs on marine debris issues. The U.S. Congress further directed NMFS to evaluate problems caused by marine debris and to take steps to mitigate them. Public education continues to be a major focus of the MERP, and to meet this responsibility a contract was issued to the Center for Marine Conservation (CMC) in late 1988 and continued through 1991 to establish Marine Debris Information Offices (MDIO). These offices provide the public with printed materials, posters, photos, and videos relating to the marine debris issue. This program has been overwhelmingly successful at providing a high volume of quality educational materials to the public. Resource materials are also provided to educators and to the media through these offices. In 1990, the number of requests for information more than doubled over those received during 1989, and the volume of delivered material tripled. The MDIOs responded to almost 13,000 requests for information in 1990 and distributed nearly 350,000 brochures and other materials. While the majority of requests were from individuals, almost 2,500 were from organizations and government agencies seeking multiple copies of materials. During 1991, the MDIOs responded to more than 16,000 requests for information, 3,500 of which were for multiple copies of materials, and distributed 304,000 brochures and other materials.

Other education and public awareness projects funded by the MERP during 1990 and 1991 included a Sea Grant project, the Puerto Rican Port Project and Symposium, which set up a port/marina refuse reception facility in Fajardo, PR, and translated marine debris education materials into Spanish. The First International Ocean Pollution Symposium was held in April 1991 at Parquera, PR, to report results and to discuss regional problems and issues. The MERP has received the draft report from this project. A cooperative effort with the U.S. Coast Guard and U.S. Coast Guard Auxiliary to distribute MARPOL V information packets to boaters was initiated in 1990 and continued through 1991. The Pacific Regional Marine Debris Awareness Project, a Sea Grant project, received funding in 1991 to produce regionally oriented marine debris educational materials for distribution within the diverse island cultures of the Pacific Islands. The "Proceedings of the Second International Conference on Marine Debris" convened in Honolulu, HI, in April 1989, was released in December 1991.

MITIGATION PROJECTS

During 1990 and 1991, two projects were supported to directly reduce the marine debris problem: The National Beach Cleanup Campaign and the removal of debris from Hawaiian Monk Seal Beaches. Both continue to receive MERP funding.

The National Beach Cleanup Campaign is cofunded with the Environmental Protection Agency (EPA). During the 1990 cleanup campaign, 108,000 citizen volunteers removed 2.6 million pounds of debris from 3,700 miles of the U.S. coastline. Preliminary results for 1991 show that 118,000 volunteers collected 2.5 million pounds of debris from 3,800 miles of the U.S. coastline.

The MERP funds the Hawaiian monk seal (*Monachus schauinslandi*) project through the NMFS's Southwest Fisheries Science Center. Research teams working to understand and to protect the endangered monk seals make annual trips to hauling and pupping beaches in the northwest Hawaiian Islands. Researchers gather, catalog, and destroy entangling material that washes ashore in this critical habitat.

Projects initiated in 1990 and continued through 1991 include two studies of the economic aspects of marine debris and the production of a marine debris survey handbook (in press as a NOAA Technical Report). A new mitigation project to supplement the International Maritime Organization's "Guidelines for the Implementation of MARPOL Annex V" was initiated in 1991.



A volunteer helps clean up a beach in Newport, Oregon, as part of the National Beach Cleanup Campaign. (Photo courtesy of the News-Times, Newport, Oregon.)

IMPACTS RESEARCH AND MONITORING PROJECTS

Plastic debris and commercial fishing gear lost or discarded at sea entangle marine mammals, seabirds, and fish and disable vessels and degrade the aesthetic quality of beaches. Since 1985, the MERP has funded marine debris surveys of Alaskan beaches through the AFSC's Auke Bay Laboratory. Deposition of trawl webbing, one of the most abundant entangling items found on Alaskan beaches, has been in decline since 1989. Continuing surveys will determine the geographic extent and significance of this downward trend.

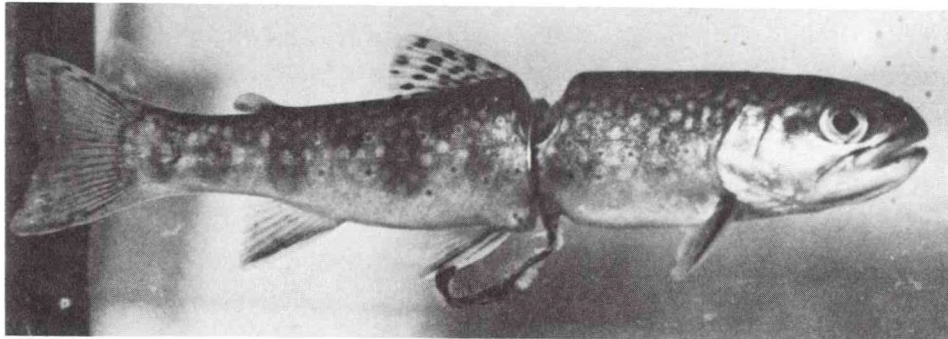
Using methodologies developed in the Alaska surveys, a national system was established in 1989 in cooperation with the U.S. National Park Service. Under this program, marine debris accumulations at sites in nine national seashores are surveyed quarterly. These sites are located throughout the East, West and Gulf Coast states and in the U.S. Virgin Islands. The data collected will be used to characterize the marine debris problem within each region and may be used to detect changes in the composition and amounts of debris over time.

During 1990 and 1991, personnel from the AFSC's National Marine Mammal Laboratory were funded by the MERP during 1990 and 1991 to continue investigations of juvenile male fur seal survival and entanglement in marine debris. This study was initiated because the declines in the fur seal population were thought to be at least partially attributable to mortalities caused by entanglement in marine debris, especially trawl net fragments. Impacts may be greatest on juvenile animals, which are more vulnerable because of their relatively small size. This work concluded in 1991. A comprehensive report is in progress.

Researchers at the University of Florida continued to study the effects of persistent marine debris on juvenile pelagic sea turtles (*Caretta caretta*). Young turtles are often associated with rafts of sargassum found in oceanic driftlines. The physical forces that establish these communities also concentrate floating marine debris along driftlines. The study investigates the effects of both entanglement and ingestion. An interim report released in March 1991 indicated that more than 50% of all turtles examined were affected by debris; the majority of these had primarily ingested styrofoam, monofilament, or tarballs.

NMFS personnel in the Northeast Region, in cooperation with the Massachusetts Division of Marine Fisheries, concluded work on a MERP-funded study to investigate the fate and impact of commercial gillnets. Experimental sections of inshore gillnet were deployed off the New England coast to assess vertical profiles and catch characteristics of the gear over time. Data will be used to help determine the feasibility of usage of degradable materials in gillnetting. A final report is in progress.

An investigation of the accumulation and buoyancy of marine debris was initiated in late 1989 and conducted during 1990 and 1991 by a private contractor. The results



A pull tab constricts a salmonid smolt found by the Michigan Department of Natural Resources.



Researchers work to free entangled animals such as this Canada goose found in Seattle with a six-pack ring around its neck.

suggest that some floating plastic debris will sink as its density increases due to fouling and then resurface due to rapid defouling, prolonging the negative effects this type of debris may have on the marine environment.

Three new projects were begun and completed in 1990. In cooperation with NMFS's Southeast Fisheries Science Center, researchers at the University of Miami investigated the effects of plastics ingestion on green sea turtles (*Chelonia mydas*). The study tested the theory that some sea turtles actively feed on some types of plastic debris (e.g., sheeting and garbage bags) because of their close resemblance to natural foods. Researchers found that green turtles actively feed on plastic debris. Among other detrimental effects, ingested plastics

caused increased intestinal gas production which increased buoyancy and affected submergence time. The other two projects involved 1) an update on information regarding debris ingestion by cetaceans which was incorporated into the "Proceedings of the Second International Conference on Marine Debris" and 2) funding of a research project to estimate the percentage of humpback whale (*Megaptera novaeangliae*) mortalities in the Gulf of Maine caused by entanglement. The data confirm that entanglement has its greatest impact on pregnant and lactating female humpbacks due to hampered feeding ability. The results also suggest that gillnets are the most prevalent form of entangling gear in the Gulf of Maine.

Two new NMFS projects were initiated in 1991. The first project investigated ghost fishing of plastic lobster pots used in Hawaiian spiny and slipper lobster (*Panulirus marginatus* and *P. penicillatus*) fisheries. This work was completed during 1991 and results indicate that ghost fishing by these traps is not a problem. The second project funded the first year of an on-going data collection effort by fisheries observers in the AFSC's Resource Ecology and Fisheries Management Division. Observers placed aboard U.S. and foreign fishing vessels operating in the North Pacific collect marine debris data in addition to their normal observer duties. Observer data will be used to characterize type, amounts and distribution of marine debris, and the amount generated by fishing vessels.

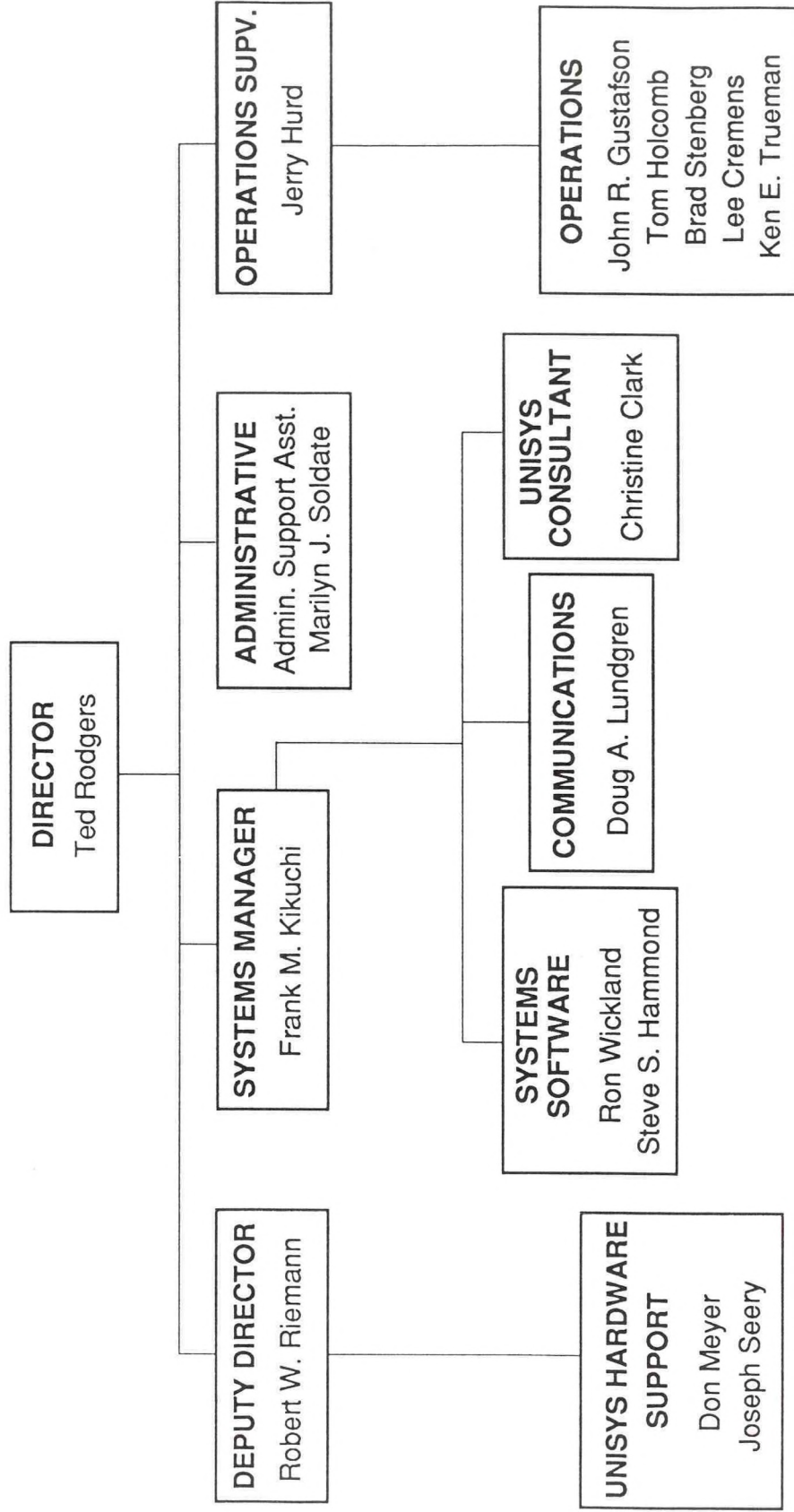
OFFICE OF FISHERIES INFORMATION SYSTEMS (OFIS)

During 1990, OFIS installed a UNISYS B7900 computer to replace the B7800 mainframe. The B7900 will serve as an interim system until the IT-95 acquisition project provides a replacement. In addition, 3.2 billion characters of on-line disk storage and a laser printer were also installed. For 1990 and 1991, OFIS managed over 14 billion characters of on-line storage for use by the AFSC, NMFS's Northwest Fisheries Science Center and Southeast Fisheries Science Center (SEFSC), and NMFS Headquarters. OFIS also absorbed the UNISYS related workload from the Bureau of Mines sites in Denver, Colorado, and Washington, D.C., while they converted their systems to a new computer. The B7900 computer system was operated with a downtime of less than 2%, thus allowing researchers to meet critical deadlines.

OFIS participated with AT&T, the DOC FTS 2000 contractor, to design the Northwest and Alaska portions of the NMFS-wide area network. The network, installed during the first quarter of FY91, will provide improved data communications between all NMFS sites. OFIS also managed a data communications network consisting of both satellite and terrestrial multiplexed communications to provide optimal computer availability to NMFS users. The network extends from the AFSC's Kodiak and Auke Bay Laboratories in Alaska to SEFSC users throughout the southeastern United States. OFIS continued to manage the regional installation and use of a remote electronic mail system which allows key personnel in field locations to exchange electronic messages and personal computer files. During 1990-91, OFIS installed a prototype local area network consisting of five workstations. Continued testing is underway and the network will be expanded to provide backup to Financial System users, with further expansion being planned.

OFIS provided technical and procurement assistance to personnel in the NMFS's Northwest and Alaska Regions in the acquisition of personal computers, software, training, telecommunications lines, and equipment. OFIS personnel completed a draft ADP Plan for the AFSC. The plan addresses networking, organizational changes, funding, and functions not being performed and offers suggestions for their implementation. OFIS also assisted NMFS Headquarters Data Management personnel in developing the final technical specifications for the IT-95 RFP. A newsletter was initiated to address items of interest to both mainframe and personal computer users. OFIS also chaired a committee of computer users throughout the AFSC to create a set of standards for personal computers and networks.

**OFFICE OF FISHERIES INFORMATION SYSTEMS
ORGANIZATION CHART
1990-91**



AUKE BAY LABORATORY (ABL)

The Auke Bay Laboratory is located 12 miles northwest of Juneau, Alaska's state capitol. The Laboratory occupies a site that offers a commanding view of Auke Bay and the surrounding mountains. Adjacent to the ABL, Auke Creek empties into Auke Bay. This small stream, which drains nearby Auke Lake, is only a few hundred yards long, but nevertheless supports runs of six species of anadromous salmonids: sockeye (*Oncorhynchus nerka*), pink (*O. gorbuscha*), chum (*O. keta*), and coho salmon (*O. kisutch*); cutthroat trout (*O. clarki*); and Dolly Varden (*Salvelinus malma*). Also nearby is the main campus of the University of Alaska Southeast.

The ABL scientific staff consists of specialists with a wide range of disciplines including fisheries biology, oceanography, ecology, population dynamics and statistics, biochemistry, and genetics. In addition, a support staff provides vital services including secretarial, computer and LAN management, library, editorial, scientific illustration, maintenance and construction, finance and purchasing, and personnel. Technicians and seasonal workers round out the staff. Facilities at ABL include a computer network servicing virtually every office and lab; an extensive marine sciences library; fully equipped chemistry, biology, and genetics labs; a wet lab with both freshwater and saltwater systems; a research museum with an extensive collection of vertebrates and invertebrates; a dock for vessels up to 100 feet; a SCUBA diving support facility; and a weir and hatchery on Auke Creek for salmonid research.

The ABL complex also includes two other important components, the Subport in downtown Juneau and the Little Port Walter field station. The Subport is a deepwater docking facility on the Juneau waterfront that serves as a staging area for NOAA vessel operations and ABL fieldwork in Southeast Alaska. It also has areas for inside and outside storage of research gear and equipment as well as fully equipped wood and metal working shops. Little Port Walter is located on the southeastern end of Baranof Island, about 125 air miles south of Juneau. Facilities include a main building, several outlying buildings, the Sashin Creek weir, floating net-pens, and a small dock. Salmonid enhancement and life history research has been ongoing here since 1932. Research is also conducted at field sites in Southeast Alaska and Prince William Sound, as well as aboard research vessels operating throughout Southeast Alaska and in the Gulf of Alaska.

Research at ABL is organized into four programs: Salmon Enhancement and Marine Recruitment, U.S.-Canada Salmon Treaty Studies, Marine Fisheries Assessment, and Habitat Research and Protection. The first two of these four programs focus almost exclusively on salmon-related research, mainly in freshwater, estuarine, and coastal marine habitats. Salmon research is also an important component of the remaining two programs. The Marine Fisheries Assessment Program encompasses high-seas salmon studies, particularly the impact of driftnet fisheries, as well as research on several marine species including sablefish (*Anoplopoma fimbria*) and rockfish (*Sebastes* spp.) in the Gulf of Alaska. The Habitat Research and Protection Program focuses on

natural and man-caused environmental perturbations that affect key species (including salmon), particularly during early life stages when year-class strength is often determined. During the 1990-91 period, the Habitat staff, with significant input from other programs, continued to play a major role in monitoring and evaluating environmental impacts caused by the massive 1989 *Exxon Valdez* oil spill in Prince William Sound.

SALMON ENHANCEMENT AND MARINE RECRUITMENT

Salmon enhancement and marine recruitment activities focus on five important objectives: 1) rebuilding depressed chinook salmon stocks through selective breeding and development of enhancement technology to produce more fish for depleted Alaskan fisheries; 2) establishing and evaluating different chinook salmon broodstocks for use at specific hatchery facilities; 3) developing new sockeye salmon enhancement technology; 4) achieving a better understanding of inter- and intra-annual variation in early marine recruitment of juvenile salmon; and 5) assessing impacts of the *Exxon Valdez* oil spill on pink and chum salmon resources. Field research on the first four objectives is carried out at Little Port Walter (including floating net-pens at nearby Osprey Bay) and at Auke Bay; Prince William Sound research is summarized with other oil spill-related studies under Habitat Research.

Chinook Salmon Research and Enhancement

A chinook salmon research program was initiated at Little Port Walter in 1976 in cooperation with the Alaska Department of Fish and Game (ADF&G) and regional aquaculture associations. This program is focused on developing technology to enhance broodstock development, egg production, marine survival, and, ultimately, the contributions made to the fishery by different stocks of chinook salmon.

Initially, the program involved two chinook stocks from the Chickamin and Unuk Rivers. In 1988, a third stock from the King Salmon River on northern Admiralty Island was added to the broodstock development program to provide eggs for enhancement projects in the Juneau area. The three stocks will also be used in important stock comparison studies. Little Port Walter is the only research facility to simultaneously maintain and study three separate chinook stocks at one location, a feat unparalleled in Pacific salmon research.

One important series of studies focuses on overwinter rearing of chinook fry under a variety of conditions including floating freshwater raceways and marine net-pens with and without an artificially created freshwater lens. Yearling chinook smolts from these studies are released into the Little Port Walter estuary. The ultimate objective is to measure production and marine survival for the various experimental groups. In conducting these studies, individual stocks are kept separate by tagging all released smolts with coded-wire tags; stock-specific tags on all returning adults are then decoded before artificial spawning takes place. Development of net-pen rearing technology promises to provide a means for increasing chinook smolt production in situations where freshwater rearing capacity is limited.

One goal of the chinook salmon enhancement program is to improve recreational fishing opportunities, especially near Southeastern Alaska population centers. In one cooperative effort involving the ABL and the ADF&G, chinook smolts are transported from Snettisham hatchery and held in saltwater net-pens at the mouth of Auke Creek for 3-4 weeks before being released at several locations in the Juneau-Auke Bay vicinity. During the first 6 years of the study, about 850,000 smolts have been released. In 1990 and 1991, 4- and 5-ocean year chinook salmon from releases in 1986 and 1987 began to return to the Auke Creek weir and have provided most of the 800 + chinooks caught in the local recreational fishery.

Sockeye Enhancement Based on Age-0 Smolts

Most sockeye salmon spend at least 1 year in fresh water before migrating out to sea as smolts. This presumed freshwater requirement for most sockeye salmon stocks seemingly made this species an unlikely candidate for artificial enhancement. Recently, the occurrence of age-0 sockeye smolts, which have limited freshwater residency, has been documented in many Alaskan river systems. As a result, there is great interest in the possibility of utilizing this life history type for large-scale enhancement of sockeye salmon. This new concept is receiving attention of the major Pacific Rim nations and is likely to have significant impacts on future sockeye salmon enhancement.

At the Auke Creek hatchery, experiments have focused on the culturing of age-0 smolts that can be released directly into seawater after less than 10 months of incubation and rearing. Seawater rearing of sockeye salmon at a small size and early age is possible due to their early development of osmocompetence. The Auke Creek study began with releases of 1987 brood sockeye salmon, and has continued with releases through the 1991 brood. Beginning in 1990, both seawater- and freshwater-reared smolts were released at several different times and sizes.

Early Marine Recruitment and Survival of Pink Salmon

For pink salmon, the first few weeks of saltwater residency are thought to be very important in terms of survival and resulting year-class strength. Recently completed research has examined early marine growth and subsequent survival for four brood years (1986-89) of Auke Creek pink salmon and has related these factors to physical and biological conditions occurring during the initial marine residency period. Fry emigrating from Auke Creek were tagged in weekly groups prior to entering seawater and subsequently were sampled, initially during their first weeks of marine residency, and later as returning adults. Food organisms and predators in Auke Bay were also sampled during the early marine residency period.

Water temperature in Auke Bay during the juveniles' residency was generally the parameter most highly correlated with growth. Food availability did not appear to limit growth except in the case of early and late outmigrants. Intra-annual survival was highly correlated with growth, but interannual variations in survival were not related to differences in early marine growth rates between year classes. This suggests that

survival, and thus year-class strength, may be strongly influenced by conditions occurring later in the life of the fish.

U.S.-CANADA SALMON TREATY STUDIES

In accordance with the Pacific Salmon Treaty between the United States and Canada, the U.S.-Canada Salmon Program provides information to the Pacific Salmon Commission (PSC) on longstanding management and allocation issues that are of concern to the two nations. ABL staff members serve on four Bilateral Technical Committees and on the Research and Statistics Committee. Technical support by ABL also assists U.S. negotiators in reaching agreements on salmon fisheries in northern British Columbia and Southeast Alaska. Research at ABL includes stock identification, stock assessment, and interception analysis for fisheries that occur in boundary areas, trans-boundary rivers, and coastwide areas.

Another major program objective is to identify the origin of salmon intercepted in high-seas fisheries, and in the process gain valuable information on ocean distributions and migrations of adult salmon. To achieve this goal requires a high degree of international cooperation, the ABL (working closely with other U.S. agencies) is undertaking collaborative studies with Russian scientists to add baseline information from Asian salmon stocks to the North American databases.

Stock Identification

Over the last several years, the ABL genetics laboratory has obtained tissue samples to establish genetic baselines for Southeast Alaska chinook, sockeye, chum, and pink salmon stocks and for chum and pink salmon stocks from northern British Columbia. To date, approximately 20 chinook salmon populations, 70 chum salmon populations, and 40 sockeye salmon populations have been sampled. Pink salmon collections have also been assembled from British Columbia, Japan, and Alaska for about 70 even-year and 80 odd-year populations. This data is being collected to determine if sufficient genetic divergence exists to discriminate Alaskan from Canadian salmon. Related work is directed at developing multi-attribute stock separation methods that combine genetic information, parasite incidence, and scale characteristics.

The data collections summarized above will also contribute to development of a genetic database for chum, sockeye, chinook, and pink salmon stocks throughout the North Pacific region that can be useful in stock separation. To assist in this effort, four Russian scientists were hosted at ABL in 1991 to jointly develop genetic baseline information on Asian pink, chum, and sockeye salmon stocks. Major goals were to identify stocks in high-seas bycatches and to eventually learn more about salmon migration routes in the Bering Sea and North Pacific. Such information can also be useful for enforcement purposes. During 1990-91, ABL responded to several requests from NMFS Enforcement Division agents to examine salmon from high-seas catches. By applying genetic,

parasite, and scale baseline data, species identities were confirmed and information was provided on probable continent of origin. Information that ABL developed on the Alaskan chum salmon baseline became an essential component of the NMFS's Northwest Fisheries Science Center's forensic analyses on salmon caught in Taiwanese high-seas fisheries and later acquired by NMFS Enforcement agents in a "sting" operation.

Stock Assessment

The Taku River, a large and turbid transboundary system, is an important producer of chinook salmon. During 1989-90, ABL tagged nearly 750

adult chinook salmon returning to this system with radio transmitters and tracked them to their spawning grounds. To accomplish this, a stationary tracking system was developed to monitor movements of radio-tagged fish. Ten tracking towers placed at key junctures on the river system recorded movement of individual radio-tagged fish past each site. A NOAA satellite (GOES) relay system provided access to this information from the ABL on a twice daily basis. Important new information was obtained on spawning distributions and relative contributions of stocks which differed between consecutive years; run timing, movement, and holding patterns within sections of the drainage were more consistent between years. Radio-tag tracking results were also used to estimate escapements of chinook salmon to the Taku River system and to refine PSC escapement goals.

Under the Pacific Salmon Treaty, chum salmon in Portland Canal, a long, narrow fjord bisected by the U.S.-Canada boundary, are identified as a conservation concern. Fish Creek, on the U.S. side of the border, supports one of the two most abundant runs of chum salmon in Portland Canal and may produce the largest chum salmon on the North American continent. In 1990-91, ABL continued to monitor returns to Fish Creek, thus adding to the 15-year data series, started in 1972, that provides an index of chum salmon stock status in Portland Canal.



Helicopter survey, Nahlin River, British Columbia. Salmon are located and observed on spawning grounds by tracking radio-tagged fish throughout large remote transboundary river drainages.

Interception Analysis

During the 1982-85 period, joint tagging experiments were conducted by the U.S. and Canada to provide estimates of salmon stock composition in Alaskan and Canadian fisheries in the northern British Columbia and southern Southeast Alaska boundary area. Adult sockeye salmon were tagged in 1982 and 1983, and adult pink salmon were tagged in 1982, 1984, and 1985. The U.S. analysis of these experiments has been completed and was prepared for publication in 1991. Each tagging experiment is described, and an analysis of stock composition and interceptions in the boundary fisheries is provided. Assessments are presented of the numbers of fish from each nation that were intercepted in fisheries of the other nation. These results are important in developing U.S. positions for treaty negotiations with Canada.

In another study, multi-attribute analyses combining parasite, scale pattern, and genetic data were used to estimate contributions of Canadian and U.S. sockeye salmon stocks in the Noyes Island and Sumner Strait fisheries. Statistical techniques were also developed to determine bias in estimating stock proportions in samples from mixed stocks when data on contributing stocks is incomplete. These techniques are being used and evaluated in fisheries managed by the PSC and the Washington Department of Fisheries. Other potential applications exist in management of many North American salmon fisheries.

MARINE FISHERIES ASSESSMENT

The Marine Fisheries Assessment Program has two major elements: high-seas salmon research and groundfish studies in the eastern Gulf of Alaska. Salmon research includes monitoring the catch of salmonids in salmon and squid fisheries operating in the North Pacific Ocean and investigating the life-history and migratory patterns of salmonids in offshore waters. These research results, in conjunction with expert testimony by ABL scientists, provide key scientific support for U.S. policy at meetings of the International North Pacific Fisheries Commission and at meetings relating to United Nations Resolution 44/225 which pertains to termination of high-seas driftnetting. The research also serves to fulfill the mandates of domestic legislation (e.g., the Driftnet Act) and international driftnet monitoring agreements.

Proximity to Alaska groundfish and their habitat has allowed the ABL to conduct field research to better understand these species and to improve our ability to assess their abundance. Research is focused on determining changes in abundance and distribution of sablefish and certain species of rockfish, particularly Pacific ocean perch (*Sebastes alutus*), shortraker rockfish (*S. borealis*), and rougheye rockfish (*S. aleutianus*). Behavioral research and life history studies are also undertaken. Based on this work, annual Status of Stock Reports are submitted to the North Pacific Fisheries Management Council (NPFMC) recommending allowable biological catch levels for sablefish, slope rockfish, and pelagic rockfish.

Salmonid Studies

One of the primary goals of the salmonid research program has been to estimate the number of North American salmonids intercepted in foreign high-seas driftnet fisheries. These include Japanese driftnet fisheries that target on salmon, as well as the pelagic squid and large-mesh fisheries of Japan and Taiwan and the squid fishery of the Republic of Korea that incidentally take salmon (and a variety of other species). Based on data from an international monitoring program initiated in 1989, an estimated 2,500 salmonids were incidentally taken in the Japanese squid driftnet fishery in 1989. This figure jumped sharply to well over 100,000 fish in 1990.

The large change in the salmonid bycatch from 1989 to 1990 led ABL scientists to study salmonid life-history characteristics and seasonal changes in distribution patterns. Based on analysis of observer data from the 1990 Japanese squid fishery, salmonid distribution near the North Pacific Subarctic Frontal Zone showed extensive variability in space and time. For example, in the western portion of the fishery, salmonid catches ranged from 0 to 2,000 fish per driftnet operation over a distance of less than 50 km. Satellite imagery showed that this large variability was associated with a diverse ocean environment that was probably generated by the interaction of ocean currents with the steep bottom topography of the Emperor Seamounts.

The extensive variability in species abundance and distribution poses special problems for Japanese efforts to test the effectiveness of alternative fishing gear (e.g., subsurface driftnets) in reducing the catch of nontarget species. ABL scientists showed that an appropriate test applicable to most nontarget species required an experimental survey consisting of at least 900 driftnet operations, a survey level many times greater than that proposed by Japan.

With regard to directed high-seas salmon driftnet fisheries, the problem is to determine both the total catch and the proportion of North American salmon. This has proven to be a difficult task. For example, data collected in 1991 by U.S. scientific observers aboard Japanese vessels showed that the salmon catch reported by vessel captains was, on the average, 28% below the observed catch. A similar bias was found in 1990.

While many key questions concerning the origin of salmon taken in various high-seas driftnet fisheries remain unanswered, recoveries of tagged salmon show a continuing presence of North American salmon in these fisheries.

Sablefish and Rockfish Research

Annual longline surveys provide the basic data used in assessing sablefish in the Gulf of Alaska. As in prior years, U.S. domestic and U.S.-Japan cooperative longline surveys were conducted in both 1990 and 1991. Staff from the ABL and the AFSC's Resource Assessment and Conservation Engineering (RACE) Division coordinated the planning and execution of these surveys. Past survey results have been ambiguous. Both surveys indicated that the exploitable biomass of sablefish decreased from 1988 to 1989, but

from 1989 to 1990 the cooperative survey indicated a substantial decrease in exploitable biomass, while the domestic survey indicated a substantial increase. The discrepancy between the two surveys was noted again in 1991, when both exploitable biomass estimates were similar to their respective 1990 levels. The reason for these ambiguous results is not understood, and the situation is under study.

In other sablefish research, analysis of tagging data produced quantitative estimates of migration between regulatory areas and has led to the conclusion that, for NPFMC purposes, there is one sablefish stock in Alaskan waters. Otoliths were also recovered from sablefish tagged previously, either as juveniles of known age or as oxytetracycline-treated individuals. These otoliths have provided a valuable means for validating ageing methods.

Past rockfish stock assessments for Gulf of Alaska stocks have been based on the Center's triennial trawl surveys. However, rough bottom conditions preclude trawling in many areas which may significantly bias available biomass estimates. To explore this problem, and to study rockfish behavior in general, observations of rockfish from the submersible *Delta* were initiated under a NOAA Underwater Research Program grant in 1989 and continued under a second grant in 1991. This work has shown that adult Pacific ocean perch are loosely schooled over smooth bottom habitat; also, Pacific ocean perch density estimates based on trawl catch rates tend to exceed those based on submersible observations in the same area. Behavioral observations have also been made on large shortraker rockfish which are encountered as solitary individuals.

In 1991, scientists of the AFSC's Resource Ecology and Fisheries Management Division (REFM), RACE, and ABL worked closely together in developing an AFSC rockfish work plan aimed at improving stock assessment capabilities. Based on earlier research, ABL scientists proposed a number of areas in which further effort is needed to improve rockfish survey methodology. These included behavior and habitat preference studies from a submersible, hydroacoustic bottom typing and biomass estimation, stock identification based on parasites and genetics, and new trawl survey sampling designs.

HABITAT RESEARCH AND PROTECTION

Natural and man-made environmental perturbations can affect finfish and shellfish species directly or through habitat impacts, particularly during early life stages when year-class strength is often determined. Potentially significant impacts come in many forms, ranging from logging and mining activities to advancing glaciers. However, since March 1989, the *Exxon Valdez* oil spill has been an overriding environmental issue in Alaska, and Natural Resource Damage Assessment (NRDA) activities have dominated habitat research priorities.

Aside from oil spill-related studies, a variety of smaller-scale research projects were initiated or continued during the 1990-91 period. Ongoing studies included: evaluation

of habitat utilization by juvenile salmonids on the Situk and Taku Rivers; surveys of debris (including trawl webbing) washed up on Alaskan beaches; research on parasites as stock indicators in both salmonids and rockfish; and investigation of a parasitic disease in Tanner crab. A study of chemical and biological baselines at Cape Krusenstern National Park was initiated in 1991 to measure contamination by heavy metals resulting from ore transport. ABL researchers also played a major role in drafting Federal and State of Alaska riparian protection laws.

Exxon Valdez Oil Spill Damage Assessment Studies

Scientists from ABL have initiated NRDA studies focusing on two major objectives: 1) monitor oil contamination levels in water, sediments, and tissues; and 2) assess biological damage to juvenile pink salmon, bottom fish, and Dungeness crabs (*Cancer magister*). These studies were part of a multiagency effort to determine injury to natural resources from the *Exxon Valdez* oil spill. Several projects were initiated within days of the oil spill in March 1989, and all continued into 1990. By 1991, field efforts in Prince William Sound began to taper off, and the emphasis shifted to hydrocarbon analyses and analyses of accumulated chemical and biological data.



ABL scientists sample sediments in Prince William Sound to determine hydrocarbon concentrations following the Exxon Valdez oil spill.

In the fall of 1991, out-of-court settlements were reached between Exxon and the State of Alaska and Federal governments. Damage assessment studies will be finished in 1991-92, and the emphasis of future studies will shift toward environmental monitoring to assess recovery and studies that aid in habitat and species restoration. Even though a settlement has occurred, public release of information is still restricted because of third party litigation that is scheduled to culminate in summer 1992.

Sophisticated laboratory analyses for hydrocarbons by ABL chemists continued in 1990-91. Research highlights in 1991 included finding the highest hydrocarbon concentrations in mussels (*Mytilus* sp.) and underlying sediments since summer 1989. Oiled mussel beds were not cleaned in 1989-90 and it was hoped that natural flushing and degradation would cleanse the beds. Some oiled mussel beds (e.g., Herring Bay) were found to contain unweathered oil in the anaerobic substrates (over 50 ppm), and overlying mussels were heavily contaminated (over 5 ppm). A linkage is suspected to continuing problems observed in sea ducks (i.e., Harlequin ducks do not breed in oiled areas) and juvenile sea otters (reduced survival rates); both are species that feed on mussels.

Pink salmon fry collected in oiled areas shortly after the spill (April, May 1989) by scientists from ABL's Salmon Enhancement and Marine Recruitment Program were contaminated with oil hydrocarbons and had reduced growth when compared to juvenile pink salmon from nonoiled areas. Subsequently in 1991, Habitat Program laboratory tests confirmed that pink salmon fry, when fed low level oil-contaminated food, show reduced growth within the first week of exposure. This finding is important because the oil spill occurred in March, just prior to the outmigration of juvenile pink and chum salmon from streams and hatcheries into Prince William Sound. Although all juvenile salmon could have been exposed to low levels of oil, it is difficult to assess the impacts of the oil spill on wild stocks). Five Prince William Sound hatcheries had releases of nearly 1 billion fry which also complicates the evaluation of wild stock returns.

Parasitology and Fisheries Management

Because habitat is an important factor in determining parasite distribution, differences in parasite assemblages can be used to distinguish stocks of host fish from areas with differing habitats. Examination of sockeye and chinook salmon for key parasites began in the late 1980s, and examination of new stocks continued during 1990-91. In sockeye salmon, country of origin can be determined with good confidence by the distribution of three parasites. The nematode, *Philonema*, for example, is present in virtually all Alaskan sockeye salmon, but absent in many non-Alaskan stocks. In cooperation with Japanese and Canadian scientists, distribution of the myxosporidian, *Myxobolus*, in chinook salmon was found to be largely limited to Asian stocks.

Some Tanner crab populations in Alaska are heavily infected with the blood parasite, *Hematodinium*. The bitter taste of infected crabs makes the product unmarketable.

Studies in 1990-91, in cooperation with the University of Alaska, have elucidated the seasonal aspects and physiological impacts associated with this parasitic dinoflagellate. This understanding may influence future harvest and management strategies.

Debris on Alaskan Beaches Declines

For several years, ABL scientists have surveyed remote Alaskan beaches to document changes in the amount of plastic debris washed ashore, especially trawl webbing that can entangle marine mammals. During 1990-91, the quantity of debris continued to decline on 8 km of Yakutat index beaches. Trawl webbing that washed ashore fell from an average of 70 pieces annually during the 1985-89 period to 43 pieces in 1990, and to only 36 pieces in 1991. Continued annual surveys of benchmark Alaskan beaches will help determine the effectiveness of the 1988 MARPOL Annex V legislation in reducing disposal of plastics at sea. Survey methods developed by ABL in this study are now also being used by the National Park Service to monitor debris on Park beaches nationwide.

Hubbard Glacier-Situk River Studies

The advancing Hubbard Glacier is predicted (with 90% probability) to close Russell Fjord during the 1990s, potentially causing massive flooding and habitat alteration in the Situk River drainage. ABL researchers in cooperation with the U.S. Forest Service and ADF&G have assessed salmonid habitat usage in the expected flood zone in order to predict changes in salmonid populations and habitat. Smolt production estimates for 1990 were 1,029,000 sockeye, 211,000 coho, 63,000 chinook salmon and 28,000 steelhead (*O. mykiss*). About 90% of the coho and chinook salmon and steelhead, and 80% of the sockeye salmon smolts emigrated from areas upstream of the flood zone and may be only slightly affected by flooding. Age-0 sockeye and age-0 chinook salmon, however, rear within the flood zone for up to 2 months prior to seaward migration and could be seriously impacted by flooding.

Protection of Salmon Habitat Becomes Law

ABL research in the mid-1980s demonstrated the effectiveness of streamside buffer zones in protecting fish habitat during logging and has resulted in significant changes in policy and law. In 1988, the NMFS Alaska Region adopted a Policy on Riparian Habitat Protection calling for buffer zones along all anadromous salmonid streams. This policy, supported by the testimony of resource managers and ABL researchers, played a significant role in the drafting and passage of two important laws in 1990: 1) The Tongass Timber Reform Act, which includes a requirement for buffer zones on all anadromous streams in the Tongass National Forest, and 2) revision of the Alaska State Forest Resources and Practices Act requiring buffer zones on all anadromous streams on public and private lands. These new laws substantially improve salmon habitat protection in Alaska.

AUKE BAY LABORATORY ORGANIZATION CHART 1990-91

DIRECTOR Snyder
DEPUTY DIRECTOR Greenough
SECRETARY Mynarski

** Program Manager
 * Task/Project Leader
 T Temporary
 LPW Little Port Walter

PACIFIC SALMON TREATY ISSUES

SALMON INTERCEPTIONS ** Olsen	
STOCK ASSESSMENT	* Carlson Bradshaw Eller Nelson Carpenter (T)
STOCK IDENTIFICATION	* Helle Hoffman * Gharrett (1) Guthrie Kondzela Hawkins (T) Noll (T) Russell (T)
INTERCEPTIONS ANALYSIS	* Pella Masuda
(1) On detail from University of Alaska.	

SALMON ENHANCEMENT AND MARINE RECRUITMENT ** Heard	
CHINOOK ENHANCEMENT	* Martin Bucke (LPW) Heintz Joyce Thrower Greiner (T)
EARLY OCEAN SALMON	* Wertheimer Celewycz Jaenicke Landingham, J. Mortensen Orsi Sturdevant Lum (T) Pritchett (T)
AUKE CREEK STUDIES * Taylor	

MARINE FISHERIES ASSESSMENT ** Dahlberg	
HIGH SEAS SALMON INTERCEPTIONS	* Dahlberg Fowler
HIGH SEAS SQUID FISHERIES	* Ignell Rumbaugh Ebberts (T) Masters (T) Murphy, J. (T) Simon (T)
MARINE RESOURCE ECOLOGY	* Haynes Haight Krieger Rutecki Wing Derrah (T) Maloney (T)
MARINE GROUND FISH ANALYSES	* Fujjoka Clausen Heifetz Sigler Varosi

HABITAT INVESTIGATIONS ** Rice	
FRESHWATER HABITAT	* Koski Johnson, S. Lorenz Murphy, M. (2) Thedinga Feldhausen (T)
MARINE ECOLOGY/OIL	* O'Clair Carla Freese (3) Stone (T)
COASTAL HABITAT/OIL	* Babcock Brodersen Korn Rounds (T)
PHYSIOLOGY/PATHOLOGY	* Moles
SPECIAL PROJECTS	Karinen
CHEMISTRY/OIL	* Short Fremgen Holland Larsen Wells Lunasin (T) Sharp-Dahl (T)
(2) Lab Safety Officer	
(3) Lab Diving Officer	

PROGRAM SUPPORT

ADMINISTRATION	INFORMATION SERVICES	PHYSICAL PLANT
Admin. Officer - Rathbone Personnel - Jones Procurement - Dunaway Property - Garrett (T) Secretarial - Morris	Library - Johnson, P. Computer - Lynk Network - Alcorn Editorial - Ramage Illustrator - Landingham, E.	Maintenance - Johnson, N. Electrical - Schrack Support - Dress Ewing (T) Weinlaeder (T)

NATIONAL MARINE MAMMAL LABORATORY (NMML)

The National Marine Mammal Laboratory is the principal Federal laboratory responsible for long-term studies on marine mammals and their interactions with fisheries in the Antarctic, Arctic, Bering Sea, Gulf of Alaska, and California Current ecosystems.

ANTARCTIC

Field research was carried out on Seal Island, South Shetland Islands (north of the Antarctic Peninsula), from 14 December 1989 to 27 February 1990, and from 4 December 1990 to 11 March 1991. The main focus of study was the ecology and population biology of Antarctic fur seals (*Arctocephalus gazella*) and chinstrap (*Pygoscelis antarctica*) and macaroni (*Eudyptes chrysophus*) penguins.

An analysis of stomach and fecal contents of live adult and subadult fur seals and penguins in 1990 showed that krill (*Euphausia superba*) were predominate in the diets of all three species, especially the penguins. Prey fed to penguin chicks by their parents contained 99% krill by weight. The diet of fur seals varied from principally krill (62%), to fish (13%), to mixed krill and fish (25%). Traces of squid beaks were found in 15% of the fur seal scat samples. Time-depth recorders and radio transmitters were attached to 14 fur seals, 10 macaroni penguins, and 40 chinstrap penguins to assess foraging behavior. Fur seals and the penguins foraged at depths averaging 20-30 m and 35-50 m, respectively. All three species swam to areas 11-100 km north of Seal Island to feed (water depths varied from 200 m to greater than 3,000 m). These results are consistent with the data collected in 1988 and 1989. Based on analyses of stomach contents and scats, chinstrap penguins were found to feed mostly on large adult female krill and immature male krill. Ship tows in areas where penguins were feeding collected a low proportion of adult female krill in relation to the entire catch; immature male krill were rarely seen in tow samples. Dive profiles of the fur seals were deeper in the water column than were the patches of krill in the same area.

Cooperative research with Chile and Japan during 1990-91 resulted in identifying the offshore foraging areas of fur seals and penguins. Fur seals foraged up to 240 km offshore of Seal Island, whereas chinstrap and macaroni penguins, respectively, only foraged up to 25 and 15 km offshore. The total number of chinstrap penguin chicks raised to creching age at Seal Island was lower in 1990-91 than in the previous three seasons. This pattern suggests that conditions may have been relatively poor prior to egg laying (i.e., fewer eggs laid), but that conditions were favorable during chick-rearing (i.e., hatched chicks survived well). No field studies were conducted on pack ice seals in 1990-91 because no ship time was available for working in the Antarctic pack ice zone.

ARCTIC

Field research on bowhead whales (*Balaena mysticetus*) was carried out from 16 April to 7 June 1990 and from 15 April to 12 June 1991 off Barrow, Alaska. Bowhead whales were photographed from a high-wing airplane using a three-camera 70-mm medium format stereographic array linked to an on-board computer able to simultaneously record aircraft instrumentation (e.g., radial altimeter) and sighting information. Photographic images recorded by this system are used to measure the body lengths of whales and to identify individual animals for life-history studies on growth and maturation, length (and possibly age) at first parturition, calving interval, and juvenile survival. The NMML bowhead whale photo-identification collection now contains over 2,500 images with sufficient markings for reidentification purposes.

A total of 428 different bowheads were photographed in 1990, including 32 females with calves. This was a 40% increase in the number of animals photographed in 1989 ($n = 257$, including 19 females with calves). The first between-year matches of identified females with new calves were made in 1990: two females with calves were observed at 48-month intervals, and one female was resighted with a calf in just over 84 months. Because the 84-month sighting could have been a female who lost a calf 3 or 4 years earlier, these records suggest that the calving interval could be about 3-7 years. No additional pairs of adults were reidentified in 1991 with calves more than once between years. The combined data set suggests a calving interval of approximately 4 years.

In 1991, a total of 299 bowhead whales were photographed including 16 calves. This compares favorably with other years, ranging from 257 to 738 photographed per year. There were extensive periods of very low cloud ceilings or fog in 1991, thus limiting flights to half of the available days. Preliminary analyses in 1990-91 of the entire database of previously measured whales indicates that the population is composed of 41.8% sexually mature adults (13 m in length), 53.0% immature individuals, and 5.2% calves. This high proportion of immature whales suggests that the population may be increasing in size. Census data collected by scientists from the North Slope Borough and University of Washington confirm this finding.

A High-8, 8 mm video camera was used in 1990 and 1991 as a tool to collect photo-identification images. This system has several advantages over the still images, including increasing the number of images per whale, thus increasing the chances of getting a high-quality image; higher shutter speeds affording stop-frame action for better identification of individual animals; the images can be reviewed at the time they were taken to ensure that all whales were properly photographed; and the data can be transferred and analyzed directly by our computerized electronic "image-grabbing" system (digital to digital). In addition to photographing bowhead whales, test counts were made of harbor seals (*Phoca vitulina*) and Steller sea lions (*Eumetopias jubatus*) with remarkable success.

BERING SEA AND GULF OF ALASKA

Steller Sea Lion

On 26 November 1990, NMFS listed the Steller sea lion as threatened under the U.S. Endangered Species Act. Since the 1960s, the species has declined by over 70% throughout its range. Research in 1990 and 1991 addressed the abundance and foraging behavior of sea lions in Alaska to assess current trends and their potential interaction with commercial fisheries. Two scientists from the Soviet Union participated under the U.S.-U.S.S.R. Environmental Protection Agreement, Area V.

Aerial and ship-based surveys were carried out from Southeast Alaska to the western Aleutian Islands, Alaska, between 11 June and 27 July 1990. A total of 37,626 sea lions were counted in 1990 compared with 38,860 at the same sites in 1989. The number of animals counted increased in the eastern Aleutian Islands (+25%) and central Aleutian Islands (+5%), showed no change in Southeast Alaska and the western Gulf of Alaska, and decreased in numbers in the eastern Gulf of Alaska (-14%) and central Gulf of Alaska (-18%). The decreases in the eastern and central Gulf of Alaska are essentially equal to the average annual decline observed between 1985 and 1989. Aerial surveys were also completed in June and July 1991. A total of 36,459 adult and juvenile sea lions were counted at 103 trend sites. This represented a net decrease of 4.4% in counts from 1990. None of the changes since 1989 and 1990 were statistically significant.

In January 1990, an adult female Steller sea lion in the Gulf of Alaska was fitted with a satellite transmitter (which reports, among other things, depth of dive and location) to study its foraging behavior during the critical winter feeding period, and to test the transmitters. The animal went to sea on at least eight feeding trips over a 46-day period; most trips were out to 90 km from the tagging site at Marmot Island in the central Gulf of Alaska. One trip was out to 250 km. In June 1990, 15 satellite transmitters were fitted to 14 adult females (with pups) and 1 adult male at various sites between Marmot Island and Kiska Island (western Aleutian Islands). Depth recorders were also attached to these animals. Most of the feeding trips lasted less than a day and were generally within 30 km of the rookery. Depth of presumed foraging dives averaged 25-30 m (many dives were to 50 m with the deepest dive to 140 m), and the dives lasted about 95-100 seconds in duration. Most dives were at night or in the morning.

In December 1990 and January 1991, satellite tags were deployed on five postpartum female sea lions at Chirikof Island (western Gulf of Alaska) and Marmot Island. The results indicated that the range of foraging trips and dive depths are further offshore and deeper in winter than in summer. Four instruments were deployed on two pups and their mothers in November 1991. Three instruments transmitted well (two on pups and one on a female). One pup stayed close to the Ugamak Island (eastern Aleutian Islands) tagging site and one traveled as far as the Pribilof Islands. The tagged female focused her land visits at the tagging site but made foraging trips to Akun Island about 50 km away.

The Kuril Islands, U.S.S.R. were revisited in summer 1991 to follow up on a study begun in 1989. Eight satellite transmitters were fitted onto adult female sea lions, along with counts and flipper tagging, to assess long-term changes in the population. Although not all study sites were visited, the number of animals was not significantly different than 1989. Pups tagged totaled 400 animals at three sites. Eleven tagged or branded animals (1.1%) were seen in 1991 out of 739 marked in the Kuril Islands in 1989.

Blood was collected from 17 pups in Southeast Alaska in 1991 to study their hematocrit levels and general physiological condition. On Marmot Island, blood was drawn from 11 pups and then again from 10 of the same pups 5 days later. In the western Gulf of Alaska/eastern Aleutian Islands, blood was drawn from 24 pups and 6 adults for hematocrits and other condition indices. Measurements for weight, length, and blubber thickness were taken from 106 pups. Thirty-one pups were reweighed. The results are pending.

Northern Fur Seal

Northern fur seals (*Callorhinus ursinus*) were studied at their breeding rookeries on the Pribilof Islands, Alaska (St. Paul and St. George Islands), in the southeastern Bering Sea, on Bogoslof Island in the central Aleutian Islands, and on San Miguel Island in the California Channel Islands. The migration patterns of adult females were also studied using radio tags.

Routine counts of adult male fur seals and sample mark-recapture estimates of pup abundance were carried out on the Pribilof Islands in July and August 1990. The number of harem bulls (those that hold territories) was significantly less (27%) on St. George Island compared with 1989, but their numbers were slightly higher on St. Paul Island. The number of idle (nonharem) adult males increased significantly on both islands (30% on St. George Island and 16% on St. Paul Island). Counts in 1991 of territorial and non-territorial males 7 years of age and older show that the number of males increased again on St. Paul Island but decreased on St. George Island.

The estimated number of pups born on St. Paul Island was not significantly different in 1990 than in 1989, and there was no significant trend in pup production on St. Paul Island between 1981 and 1990. Pup production on St. George Island, however, continued to decline at 6.0-6.5% per year (the most recent decline began in about 1975). The differences in the dynamics of the two herds is unknown. Counts of fur seals on Bogoslof and San Miguel Islands indicate that these small herds continue to grow slowly at less than 10% per year.

Fishing nets and other debris were removed from 26 fur seals on St. Paul Island during studies of the rate of entanglement in juvenile animals (22 were entangled in trawl net, 2 in packing bands, 1 in gillnet, and 1 in twine) in 1990. The rate of entanglement in the population (0.36% in 1990) has not changed significantly since 1985. Two Japanese scientists also participated in this year's work on the entanglement of fur seals in the Bering Sea.



A NMML scientist collects dead fur seal pups on a rookery on St. George Island, Alaska, during ongoing neonatal mortality studies. The portable observation box was originally designed by Russian fur seal scientists.

Based on an examination of 371 dead pups on St. Paul Island in July and August 1990, a new pathological condition was discovered that causes severe muscle lesions (called White Muscle Disease). The disease seems to have occurred principally in animals on one rookery near the village of St. Paul Island but also occurred on isolated rookeries up to 15 km away. About 25% of the dead pups examined had the disease. However, analyses of dead animals necropsied in late fall 1990 indicated that the disease had abated (no symptoms were found in older pups). The source and impact of the disease is unknown.

In cooperation with a scientist from the Scripps Institution of Oceanography, 100 adult females and pups were fitted with radio transmitters in 1990, and their movements out of the Bering Sea were recorded using remote receivers at five sites in the Aleutian Islands. Preliminary results suggest that the migration is well dispersed across the southern Bering Sea and through most passes of the eastern and central Aleutian Islands. Radio-tagged pups averaged about 10 days traveling time from St. Paul Island to the Aleutian Islands. They dispersed widely as they traveled through the Aleutian Island passes and entered the North Pacific Ocean. Satellite tags were fitted to five adult female fur seals on St. Paul Island in late autumn 1990 to track their migration patterns. Four of the five females were monitored as they migrated into the Gulf of Alaska and as far south as lat. 54°N before the transmitter batteries apparently gave out. Five adult females and two adult males were fitted with satellite tags in 1991. Females migrated south through the Aleutian Island passes and into the North Pacific, while the males remained in the Bering Sea.

Two scientists from the NMML traveled to the Commander Islands, U.S.S.R., in July and August 1990 to carry out a joint U.S.-U.S.S.R. study of trends in abundance and

feeding ecology of adult female northern fur seals. The purpose of the study was to determine their foraging strategies which may help to explain the differences seen in the rates of decline in U.S. and Soviet fur seal populations in the Bering Sea. Radio transmitters were fixed onto 24 known-age females (flipper-tagged as pups). Feeding trips averaged about 4 days, or about half as long as trips by female fur seals from the Pribilof Islands. Squid was the predominant prey of Commander Island fur seals, whereas the Pribilof Islands herd consumed a mixed diet of squid and fish. Information on foraging behavior, the amount of milk transferred from mother to pup, and samples of pathogens collected from pups are all being analyzed for comparison between herds on the Commander and Pribilof Islands. Blood samples from 60 fur seals from the Commander Islands were also collected to compare with those from Pribilof Island fur seals to develop a database to help determine the island of origin for fur seals incidentally taken in the foreign high-seas squid driftnet fishery. This analysis is being carried out in collaboration with the Southwest Fisheries Science Center. Additional analyses of DNA and other tissues may be needed to assess whether mortality or immigration is the most significant contributor to the decline of fur seals on St. George Island. Use of physical characteristics was carried out as a basis for determining age composition and age-specific reproductive success of adult female fur seals. Preliminary results indicate that the age composition of mature females is younger on St. Paul Island than on St. George Island.

Exxon Valdez Oil Spill

In 1990, the study designed to assess the impacts of the *Exxon Valdez* oil spill in Prince William Sound and surrounding environs of the Gulf of Alaska on marine mammals entered its second year. Preliminary data suggest that six more resident killer whales (*Orcinus orca*) from Prince William Sound may have died, in addition to the sudden disappearance of seven killer whales in Prince William Sound in 1989. A cause-and-effect relationship between the missing whales and the oil spill has not been established but is one hypothesis being investigated.

In 1991, studies were carried out under the restoration provision of the Federal interagency agreement. Studies were only continued on killer whales and harbor seals. The results are expected to be released in late 1992 or early 1993 in a book covering research on all marine mammals.

Harbor Porpoise

Research on harbor porpoise (*Phocoena phocoena*) began in 1991 under the NMFS's Population Assessment Program to meet the 1988 amendments to the Marine Mammal Protection Act (MMPA). Abundance estimates of harbor porpoise in Alaska in 1991 were obtained using line-transect methodology. Data were collected during ship surveys in Southeast Alaska in spring, summer, and fall, and during aerial surveys in Cook Inlet and Bristol Bay in late summer. Large concentrations of harbor porpoise

were encountered in Southeast Alaska with abundance estimates of approximately 1,000-4,000 animals. Aerial survey efforts in Cook Inlet and Bristol Bay yielded low numbers of harbor porpoise in Bristol Bay, an estimated 3,000-7,000. No harbor porpoise were seen in Cook Inlet.

CALIFORNIA CURRENT ECOSYSTEM

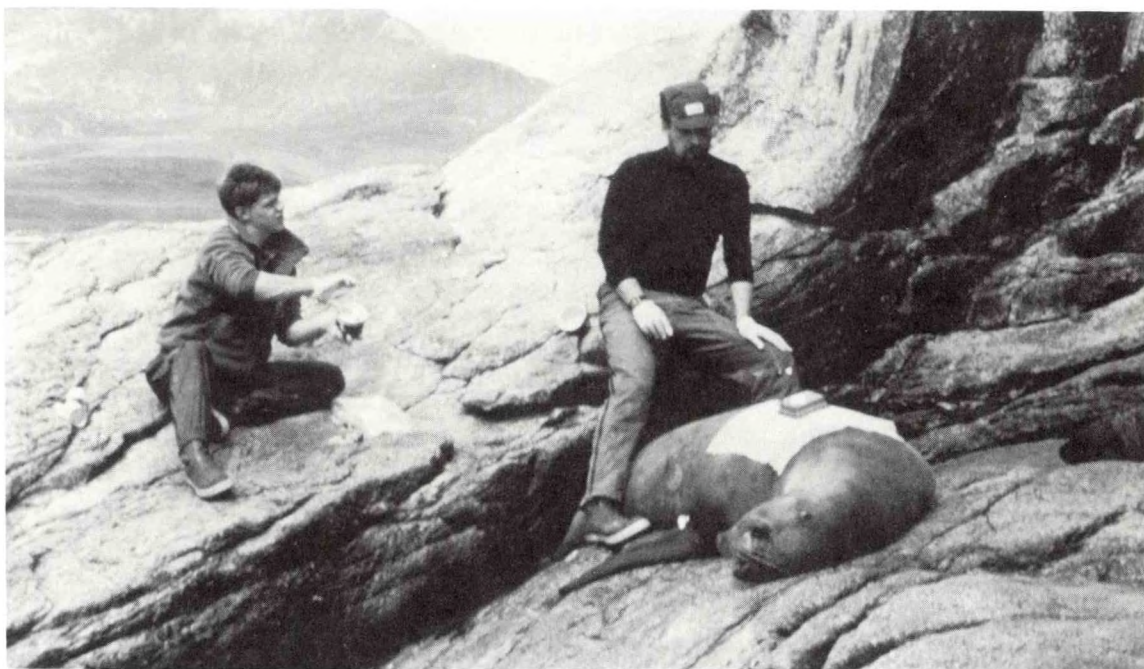
Northern Elephant Seal

The foraging behavior of northern elephant seals (*Mirounga angustirostris*) has been studied at San Miguel Island, California, for the past 4 years to help understand the limiting factors associated with rapidly expanding pinniped populations. Work in 1990 was designed to determine where and how elephant seals feed between the breeding season (late winter) and the molt (summer). Time-depth recorders, which also calculate surface positions at sea, were placed on eight adult females and eight adult males in February 1990 and were recovered in May (females) and July (males). The females migrated to lat. 40-45 N, long. 140-160 W to feed, or about 2,000 km from San Miguel Island. Their deepest dives exceeded 1,400 m, and as in 1989, diving behavior was generally continuous for the 60 to 90-day foraging trip. So far, parts of 11 different species of squid have been found in the stomachs of the female seals (sampled from live animals). Five instruments were recovered from the males. One adult male migrated to the Aleutian Islands to feed (as did two others in 1989), whereas the other four adult males foraged in the eastern Gulf of Alaska and deeper water off the Queen Charlotte Islands, Canada. Eight adult females and eight adult males were fitted with time-depth recorders again in May and July 1990, respectively, to evaluate movements between the molt and breeding seasons. Animals of both sexes again migrated to the areas where they had been earlier in the year. This suggests that adults annually undertake two long migrations.

Harbor Porpoise

The incidental take of harbor porpoise in the Makah Tribal set-net fishery along the coast of Washington was monitored in July and August 1990. The estimated take ($n = 13$) was less than in 1989 ($n = 23$) and significantly less than in 1988 ($n = 102$). The differences between the take in 1989 and in 1990 compared to that of 1988 were a result of reduced fishing effort by the Makah fishermen. Aerial surveys along the outer coast of Washington were also conducted in 1990 to determine the population size of harbor porpoise as part of NMFS's MMPA Population Assessment Program. Preliminary results support the minimum population estimate of 700 animals made in 1989 for the nearshore area off the north coast of Washington.

In collaboration with Cascadia Research Collective, NMML scientists conducted aerial surveys from 7 July through 22 September 1991 to determine a minimum population estimate for harbor porpoise along the coast of Washington and Oregon. Preliminary



A NMML scientist attaches a radio tag to an adult female sea lion in the Aleutian Islands, Alaska.

results suggest that the population size in Oregon is possibly 3,000-11,000, and in Washington waters 5,000-18,000 (using approximate lower ends of the 95% C.I. of the uncorrected and corrected estimates; the coefficient of variation was usually less than 0.15).

California Sea Lion

In 1990, six adult male California sea lions (*Zalophus californianus*) were captured, radio-tagged, and transported by horse trailer and barge from Washington State to San Miguel Island, California, in an effort to reduce depredation on a severely reduced wild population of steelhead trout (*Oncorhynchus mykiss*) at the Hiram Chittenden Locks and Lake Washington ship canal fish ladder in Seattle. In 1989, 37 animals were fitted with radio transmitters and transported to Long Beach, Washington. One animal (No. 21), which was originally captured in February 1989, and twice shipped to Long Beach, Washington, was observed on San Miguel Island on 4 and 23 July 1989. This animal was recaptured again on 12 March 1990 and shipped to San Miguel Island on 21 March 1990. It was then seen on 4 May 1990 near Everett, Washington (north of Seattle). A second animal (No. 35) was similarly captured in February 1989, translocated to Long Beach, Washington, and then observed on San Miguel Island on 21 July 1989. The next sightings were near Everett, Washington, on 9 April and 5 May 1990. As predicted, steelhead escapement rates did not increase in either 1989 or 1990. Translocation of sea lions is not a permanent solution to keeping the sea lions away from the Seattle-Everett area, but it may eliminate the immediate predation pressures on the steelhead. To do so, though, all or at least most of the sea lions must be physically removed a considerable distance, such as to their breeding grounds on the California Channel Islands.

California sea lions and northern fur seals were counted and studied at San Miguel Island in July and August 1991. The mean of two counts of live sea lion pups was 16,235, and the count for dead pups was 1,968. A total of 1,516 fur seal pups were counted.

Harbor Seal

Aerial surveys were flown in Washington and Oregon during the pupping and molting seasons in 1991 to determine the optimal time to census harbor seals. This work is also being carried out under the NMFS's MMPA Population Assessment Program. In three areas of Washington (coastal estuaries, eastern Strait of Juan de Fuca, and southern Puget Sound), 84 VHF radio transmitters were attached to flipper tags of harbor seals to determine how many animals might be missed during aerial surveys counts. A correction factor, based on the proportion of radio-tagged seals hauled out during aerial surveys, was used to make preliminary estimates of the total number of harbor seals in Washington. Coefficients of variation for abundance estimates were less than 0.20 in all cases with multiple surveys and lower than the 0.30 target value. The counts for Washington, which are provisional pending final analysis, were highest during the pupping season (23,199). The correction factor ranged from 1.5 to 1.8, giving a preliminary state-wide estimate in excess of 30,000 harbor seals. For Oregon, the highest counts were obtained during the molt season (6,958). The correction factor for Oregon will not be determined until 1992.

The NMML began a cooperative population assessment of harbor seals in Alaska during 1991. Surveys were carried out during June and August/September and will continue in 1992 and 1993. Minimum population estimates were obtained for Bristol Bay, Prince William Sound, and the Copper River Delta during August and September 1991 by conducting repetitive aerial surveys. The north side of the Alaska Peninsula was also surveyed during June to obtain comparative counts and to determine trends there. The study consisted of four to five repetitive aerial surveys lasting 2-3 weeks that were flown between 300 and 500 feet (wind permitting) at about 80 knots.

A sum of mean counts from all survey areas totalled 13,708 harbor seals counted during 1991 molt surveys (Eastern Bristol Bay = 750; Alaska Peninsula (south side) = 7,896; Copper River Delta = 3,491; Prince William Sound = 1,571. The coefficient of variation ranged from 0.087 for the north side of the Alaska Peninsula to 0.227 for eastern Bristol Bay. About 900 additional harbor seals were counted in Prince William Sound by the Alaska Department of Fish and Game in conjunction with *Exxon Valdez* Natural Resource Damage Assessment studies. This number, added to the above total, results in about 14,608 harbor seals within the study areas during molt surveys in 1991. Counts from the June surveys conducted along the north side of the Alaska Peninsula totalled about 8,962 harbor seals.

HIGH-SEAS FISHERIES INTERACTIONS

The principle focus of research on the high seas is to assess the incidental take of marine mammals in the foreign driftnet fisheries operating in the North Pacific. In 1991, results were released from observer programs in each of the five driftnet fisheries operating during the period between May 1990 and May 1991. A total of 5,300 fishing operations on 143 vessels were monitored. The observed bycatch of marine mammals totaled 3,541 cetaceans and 581 pinnipeds. These totals are broken down by fishery and species in Table 1. Northern right whale dolphin (*Lissodelphis borealis*), Pacific white-sided dolphin (*Lagenorhynchus obliquidens*), Dall porpoise (*Phocoenoides dalli*) and northern fur seal were the most commonly caught species in the squid fisheries. In the fisheries directed at albacore (*Thunnus alalunga*), striped dolphin (*Stenella coeruleoalba*), common dolphin (*Delphinus delphis*), and northern right whale dolphin were the most common bycatch species.

STATUS OF ENDANGERED WHALES

A 5-year status of stocks report on the eight large whales listed as endangered under the U.S. Endangered Species Act (ESA) was completed in 1990. More than 2.5 million large whales have been killed by commercial whalers over the past 300 years. Only one population (the Atlantic gray whale (*Eschrichtius robustus*) in the 1700s) has become extinct since the 1600s. Most stocks of whales are well below 60% of their estimated initial abundance at the time commercial whaling began (60% is the approximate level below which large whales are considered depleted under the MMPA and ESA). Seventy percent of the identified stocks of whales around the world are 25% or less than their initial stock size presumably at or near the beginning of commercial whaling. Of the 21 major ocean basin populations of large whales, 5 are less than 5% of their initial abundance. Although there is considerable uncertainty about the precise status of many stocks of whales, sufficient data are available to conclude that, as species, right (*Balaena glacialis*), blue (*Balaenoptera musculus*), fin (*Balaenoptera physalus*), humpback (*Megaptera novaeangliae*) and bowhead whales, and perhaps sei whales (*Balaenoptera borealis*) are severely depleted world-wide, whereas gray whales and sperm whales are not. On 22 November 1991, the eastern North Pacific population of gray whales was recommended by the NMFS for removal from the ESA list of endangered species.

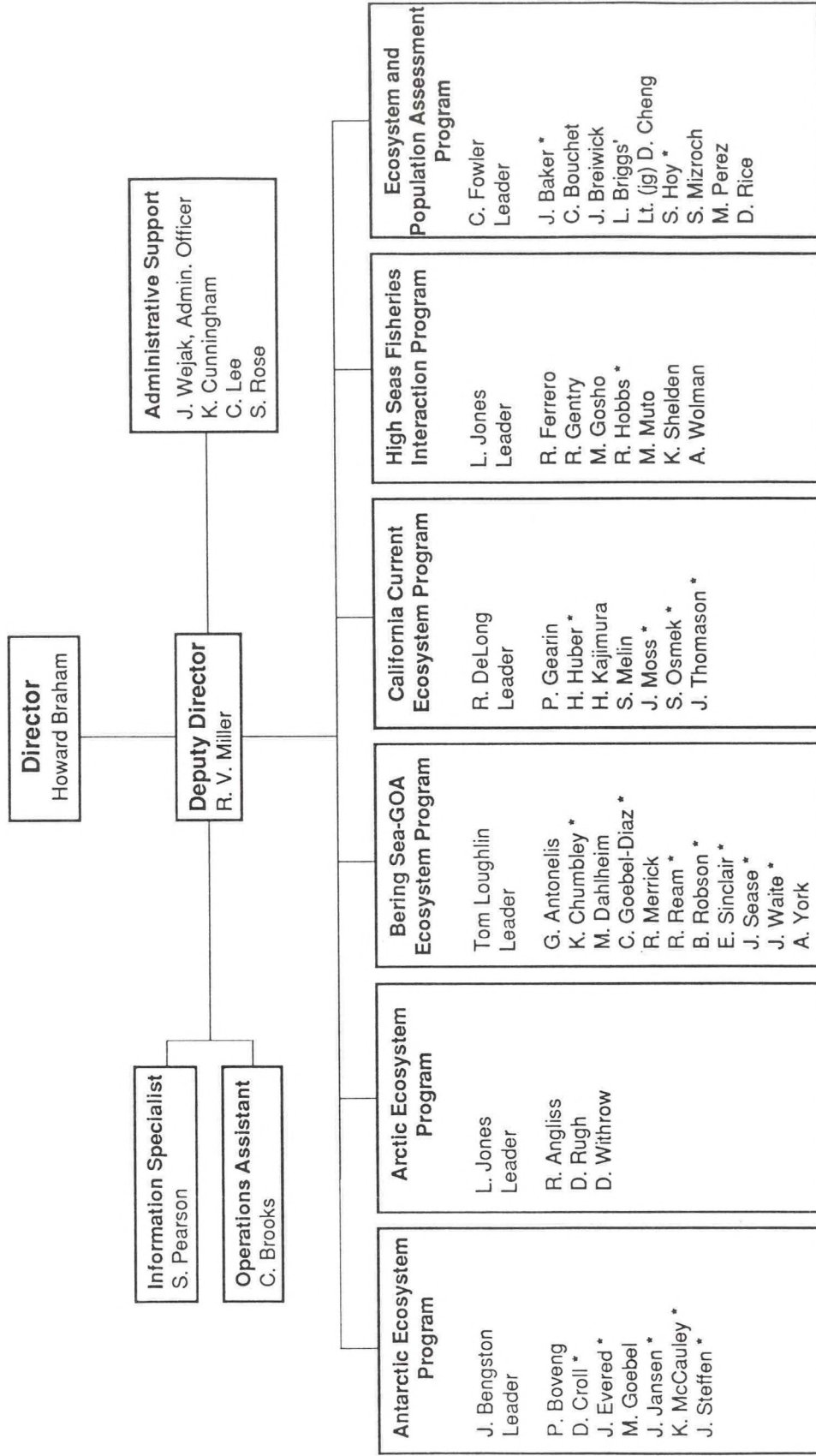
Table 1. Composition of observed bycatch of marine mammals by fishery in the high seas driftnet fisheries in the North Pacific Ocean, 1990. Numbers include the total number of animals caught including those dead, released alive, and of unknown condition.

Species		Squid			Large-mesh	
		Japan	Korea	Taiwan	Japan ¹	Taiwan
Pinnipeds	N. fur seal	545	4			12
	Elephant seal	1				
	Unidentified	19				
	Total pinnipeds	565	4			12
Dolphins	Unidentified		2	4	152	201
	N. right whale	840	54	7		41
	Pacific white-sided	459	29	5	6	6
	Common	69	6		479	47
	Striped	6	1		500	21
	Spotted				37	
	Bottlenose	1			15	2
	Rough-toothed				18	
	Risso's	2			29	1
	Pygmy killer whale				17	
	False killer whale	2			7	
	Short-finned pilot	3				
	Unid. black whale	1			5	3
	Unid. small	41				
Porpoise	Dall's	318	23	2		1
Whales	Cuvier's beaked	2			2	
	Pygmy sperm	1			20	3
	Dwarf sperm					1
	Sperm				4	
	Minke				1	
	Unidentified	12	1	1	26	4
TOTAL cetaceans		1,757	116	19	1,318	331
No. of operations monitored		2,879	911	356	826	358
Amount of net monitored(tans ²)		2,281,895	669,662	170,415	511,589	194,953

¹ Excludes bycatch in Japanese coastal waters.

² Tan is standardized to 50m of net.

NATIONAL MARINE MAMMAL LABORATORY 1990-91



* Temporary Employee

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING (RACE) DIVISION

The RACE Division continued its program of resource assessment to provide scientific information for the management of marine fish and shellfish. During 1990-91, major resource assessment surveys were conducted in the Gulf of Alaska and Bering Sea and throughout the Aleutian Islands region. Special purpose surveys were also conducted in waters off Oregon and California to obtain relative indices of sablefish abundance and in the vicinity of Kodiak Island to examine fish behavior in and around trawls. The Division continued to support mesh size selection studies by the Fisheries Research Institute, University of Washington, a program which is also assisted by Saltonstall-Kennedy funds and the Washington Sea Grant Program. Research continued on recruitment processes through the Fisheries-Oceanography Coordinated Investigations (FOCI) study in Shelikof Strait, in addition to studies on fisheries pathology, ecology, acoustics, and gear performance. These activities were supported by RACE data management and gear maintenance groups.

GROUND FISH ASSESSMENT

Bering Sea Groundfish Assessment

The Bering Sea Groundfish Subtask, in conjunction with the Shellfish Assessment Task at the Kodiak Facility, conducts annual bottom trawl surveys to assess the condition of the important groundfish and crab resources in the eastern Bering Sea. The 1990 and 1991 bottom trawl surveys were the 12th and 13th consecutive years in which a standard survey area encompassing a major portion of the eastern Bering Sea continental shelf has been sampled in this time series. In 1991, the fifth in a series of expanded triennial surveys was also completed. This survey included northern sections of the continental shelf in Norton Sound and the continental slope. During triennial survey years, the shelf and slope are sampled using echo integrator/midwater trawl (EIMWT) techniques, as well as with bottom trawls.

Results of the 1990-91 surveys have shown that most groundfish in the eastern Bering Sea remain in excellent condition. The estimated biomass of walleye pollock (*Theragra chalcogramma*) in 1990 (7.7 million metric tons (t)) was the highest recorded during the present time series of bottom trawl surveys. The 1991 estimate was 5.1 million t. Independent assessments by population dynamicists at the Center also indicate that the abundance of pollock has been stable or has declined moderately but remains in good condition. The sampled population continues to consist of larger and older fish when compared to samples from earlier years. The abundance of Pacific cod (*Gadus macrocephalus*) remained at a high level of near 1.0 million t from 1981 to 1989. The 1990 and 1991 estimates dropped significantly to 709,000 t and 533,000 t, respectively. Again, independent assessments show a similar trend. Almost all species of flatfish increased markedly in abundance. Yellowfin sole (*Pleuronectes aspera*) remains very high with a 1991 estimate of nearly 2.4 million t. Rock sole (*Pleuronectes bilineata*) is among those

species demonstrating remarkable increases since the late 1970s. The estimate for 1991 is now 1.6 million t, or about 8 times the estimate for 1979. Flathead sole (*Hippoglossoides elassodon*), Alaska plaice (*Pleuronectes quadrituberculatus*), and arrowtooth flounder (*Atheresthes stomias*) biomass estimates have shown 2-11 fold increases during this time period as well. The Greenland turbot (*Reinhardtius hippoglossoides*) is the only flatfish species of concern. The survey data have shown very low recruitment of juvenile Greenland turbot since the early 1980s and the recent survey results show a continuation of the trend. The adult biomass which occupies continental slope waters has leveled at approximately 40,000 t.

The fluctuations in abundance of eastern Bering Sea groundfish seem to be mainly the result of variability in recruitment. Nearly all of the flatfishes have benefitted recently from the recruitment of large year classes. Increases in abundance of cod and pollock resulted from very strong year classes spawned in 1977 and 1978, and abundance has been maintained at high levels by moderately strong recruitment in 1982 and 1984. Evidence from the surveys indicates that the 1990 year class for pollock is considerably above average, and the 1989 year class may also be above average. Although recruitment strengths for Pacific cod are more difficult to estimate than pollock, it also appears that the 1989 and 1990 year classes for cod may be above average.

During 1990 and 1991, the United States and U.S.S.R. continued to cooperate in the assessment of groundfish in the Bering Sea. In 1990, the survey region included the eastern Bering Sea and northern and western Bering Sea shelves to Cape Olyutorski. In 1991, the sampling area was extended farther west along the continental shelf to Karaginski Island. These surveys have provided the first sets of standardized data which could be used to define the distribution, abundance, and population characteristics of groundfish and invertebrates in both the eastern and western portions of the Bering Sea. The results of the 1990 survey indicate that many of the same groundfish species occur in both Soviet waters and the eastern shelf, but overall groundfish abundance over the western continental shelf is significantly lower compared to that over the U.S. shelf. Pollock and cod were the predominant species in the western portions of the Bering Sea. Analysis of the 1991 data is still in progress.

Gulf of Alaska Groundfish Assessment

During 1990-91, research activities included comprehensive bottom trawl surveys of the western and central Gulf of Alaska and Aleutian Islands, the annual domestic longline survey of the Gulf of Alaska, and the cooperative Japan-U.S. longline survey of the Aleutian Islands, Bering Sea, and Gulf of Alaska.

The third comprehensive triennial bottom trawl survey of the western and central Gulf of Alaska groundfish resources was completed during the summer of 1990. A total of 508 preselected stations were successfully sampled from the Islands of Four Mountains (long. 170°00' W) to Cape St. Elias (long. 144°30' W) at depths ranging from 20 to 513 m. Arrowtooth flounder was the dominant species in the central and western Gulf with a biomass of 1.7 million t followed by walleye pollock (767,000 t), Pacific cod (380,000 t),

and Pacific halibut (*Hippoglossus stenolepis*) (314,000 t). Other important flatfish species were flathead sole (222,000 t), rock sole (157,000 t), rex sole (*Errex zachirus*) (81,000 t), and Dover sole (*Microstomus pacificus*) (72,000 t). The major components of the central and western Gulf of Alaska rockfish complex were northern rockfish (*Sebastes polyspinis*) (99,000 t), Pacific ocean perch (*S. alutus*) (59,000 t), and rougheye rockfish (*S. aleutianus*) (38,000 t). Prior to 1990, Japanese vessels cooperated in bottom trawl surveys and the differences in the fishing power of the various trawls used have made the comparison of annual results difficult. New methods are being applied to the standardization of Japanese and U.S. catches so that meaningful population trends can be established in the future.

Aleutian Island Bottom Trawl Survey

The fourth triennial bottom trawl survey of the Aleutian Islands area was conducted from July to September 1991. The survey covered the southern Bering Sea from long. 165°00'W to long. 170°00'W and the Aleutian Islands from long. 170°00'W to long. 170°30'E between depths of 10 and 500 m. Atka mackerel (*Pleurogrammus monopterygius*) (688,000 t), Pacific ocean perch (408,000 t), walleye pollock (265,000 t), northern rockfish (182,000 t), and Pacific cod (184,000 t) were the dominant groundfish species, accounting for nearly 90% of the total fish biomass. The estimated biomass for the combined major flatfish species (arrowtooth flounder, Kamchatka flounder (*Atheresthes evermanni*), Greenland turbot, and rock sole) was 152,000 t.

Longline Surveys

The fourth and fifth annual U.S. longline surveys of the upper continental slope and deep gullies of the Gulf of Alaska were conducted in cooperation with the Auke Bay Laboratory from July to September 1990 and 1991. The primary objective was to determine the relative abundance and size composition of sablefish (*Anoplopoma fimbria*), shortspine thornyhead (*Sebastolobus alascanus*), and shortraker (*Sebastes borealis*) and rougheye rockfish. One hundred twenty-four longline sets were completed at 63 preestablished stations distributed between the Islands of Four Mountains (long. 170° W) and Dixon Entrance; 47 of these have been sampled annually since 1979. Sablefish abundance in the western and central Gulf of Alaska has decreased since 1989 while the abundance estimate for the eastern gulf has increased. These regional changes nearly equaled each other so when all areas are combined there is no significant change in abundance. Sablefish represented 55% of the total 1991 NMFS longline survey catch and was by far the predominant species.

During the summer of 1990 and 1991, the 12th and 13th annual Japan-U.S. cooperative longline survey was conducted in the Aleutian Islands, Bering Sea, and Gulf of Alaska. Sablefish abundance indices from the cooperative survey and NMFS survey both declined by 18% between 1988 and 1989. In 1990, however, the NMFS abundance index increased 20% but the Japan-NMFS abundance index declined 24%. While a similar intersurvey discrepancy persisted in 1991, the indices from both surveys showed very little change in sablefish abundance between 1990 and 1991.

West Coast Groundfish Assessment

A cooperative squid jigging research survey was conducted by scientists from the AFSC and Japan during August and September 1990 to determine the distribution and abundance of neon flying squid (*Ommastrephes bartrami*) and to examine the feasibility of harvesting this species with jigging equipment. Four Japanese vessels, each with a U.S. and a Japanese scientist aboard, fished at 142 stations in the U.S. Exclusive Economic Zone off Washington and Oregon using attraction lights, automatic jigging machines, and handlines. Although operations were scheduled to last 80 days beginning 1 August, the project was discontinued 34 days later on 4 September because the vessels failed to locate significant aggregations of squid. Information on catch, effort, and biological characteristics were collected from target and bycatch species.

The AFSC and the Southwest Fisheries Science Center (SWFSC) conducted two comprehensive bottom trawl surveys of continental slope groundfish resources in 1990 and 1991. The 1990 survey covered the upper continental slope (183-1,280 m) off California and Oregon from lat. 40°30'N to lat. 43°00'N. The 1991 survey covered an adjacent area to the south (lat. 40°30'-38°20'N). Primary objectives included describing the distribution and abundance of key groundfish species of the upper continental slope, especially sablefish, Dover sole, arrowtooth flounder, shortspine thornyhead, and longspine thornyhead (*Sebastolobus altivelis*), and obtaining information on population biology. Sablefish were also tagged during the 1991 survey and injected with oxytetracycline (OTC) to validate age determination techniques. Conductivity, temperature, and depth profile casts were made at selected stations to describe the physical oceanography and relate it to the distribution of slope species. As expected, species composition varied among the five depth strata examined. Pacific whiting (*Merluccius productus*) and spiny dogfish (*Squalus acanthias*) were the predominant species in water less than 550 m deep in the northern area (1991) while Pacific whiting and Dover sole were abundant in the southern region (1992). In deeper waters, longspine thornyhead, sablefish, Dover sole, and Pacific grenadier (*Coryphaenoides acrolepis*) were prevalent in both regions. The mean size for most species tended to increase with depth.

Sablefish relative abundance has been monitored since 1979 using standardized catch per unit effort (CPUE) from trap sets at standard index sites. Sampling is conducted once every 3 years in each of two regions: Washington, Oregon, and California. In 1991, nine index sites off southern Oregon and California were sampled. A string of 10 conical traps were fished twice at each of six standard depths (275, 411, 549, 686, 823, and 960 m) and additional sets were made between 1,150 and 1,550 m (7 sites). When averaged over all sites and depths, the mean number of fish caught per trap per day in 1991 was 67% lower than in 1988, 22% lower than in 1986, and 64% lower than in 1984. AFSC and SWFSC scientists cooperated to develop an age validation study of sablefish utilizing oxytetracycline (OTC) marking. In excess of 2,570 sablefish were

tagged with spaghetti tags and released. Three-quarters of those were injected with OTC. The remainder served as a control group to determine whether OTC affected the survivability of injected fish.

PELAGIC RESOURCE ASSESSMENT

Bering Sea Pollock Surveys

In 1990, two U.S.-Japan echo integration/midwater trawl (EIMWT) surveys were conducted in the Bering Sea to assess walleye pollock abundance. The first was a winter midwater trawl survey in the southeastern portion of the International Zone of the Aleutian Basin. Ninety-four percent of the female fish were in a mature (prespawning) reproductive stage. Pollock ranged in length from 39 to 60 cm, with a mean length of 49 cm. The corresponding range of ages was from 5 to 25 years, with the 1978 year class accounting for 32% of the total number aged. The second joint study was conducted during the summer and was an EIMWT survey covering the entire Aleutian Basin east of the U.S./U.S.S.R. Convention Line, as well as the eastern Bering Sea shelf inshore to a bottom depth of approximately 75 m. Adult pollock in the Basin ranged in length from 41 to 59 cm. On the shelf northwest of the Pribilof Islands, a broad range of lengths from 12 to 72 cm was observed. Biomass and age distribution results are not yet available.

In the winter of 1991, U.S. scientists conducted an EIMWT survey of waters over the eastern Bering Sea shelf southeast of St. George Island and over the Aleutian Basin near Bogoslof Island. The highest densities of pollock were observed in the vicinity of Pribilof Canyon south of St. George Island. Pollock lengths ranged from 8 to 78 cm. Most adult females were in a mature, prespawning reproductive stage. Preliminary analysis of age structures shows the 1984 and 1982 year classes to be well represented. Biomass estimates are not yet available. Very few females in the Bogoslof Island region had spawned by late February, but by early March the number of spawning or spent females exceeded those that had not spawned. The preliminary biomass estimate for the Bogoslof area was 0.6 million t. This value is down significantly from the 2.4 million t and 2.1 million t estimated in 1988 and 1989, respectively. Preliminary analysis of age structures shows that the 1978 year class still dominated that spawning stock.

In the summer of 1991, U.S. and Japanese scientists conducted a joint survey to assess all pollock east of the U.S./U.S.S.R. Convention Line. Pollock in trawl catches from basin waters generally ranged in length from 41 to 62 cm. Biomass estimates are not yet available. As in previous years, most of the midwater biomass observed over the shelf was located in the northwest portion of the survey area. In general, demersal trawl catches were dominated by pollock greater than 40 cm, whereas pelagic trawl catches most often captured smaller individuals. A preliminary estimate of the pelagic component of the stock over the shelf to within 2 m of the bottom was 1.5 million t.

Gulf of Alaska Pollock Surveys

EIMWT surveys of Shelikof Strait and adjacent areas were completed in the winter of 1990 and 1991. No substantial concentrations of spawning pollock were observed in waters beyond Shelikof Strait, which is consistent with the results of past surveys. Estimated midwater biomass in Shelikof Strait was similar for the 2 years and remained low at about 382,000 t.

SHELLFISH RESEARCH

Bering Sea Crab Assessment

With the exception of golden king crab (*Lithodes aequispina*), which frequents untrawlable grounds, all commercially important stocks of eastern Bering Sea crabs were surveyed in 1990 and 1991. The Bristol Bay red king crab (*Paralithodes camtschaticus*) stock has suffered from poor recruitment throughout the 1980s and remains currently at historically low levels. The abundance index for legal male crab was 9.2 and 12.0 million in 1990 and 1991, respectively, as compared to 11.9 million in 1989. Currently, the abundance index for sublegal males is at a historical low, leading to concern that low recruitment may continue to impact the fishery over the next several years. The Pribilof Island blue king crab (*Paralithodes platypus*) stock showed signs of improvement with abundance indices of 0.4 and 1.0 million legal crab in 1990 and 1991, as compared to 0.2 in 1989. The fishery has been closed due to low stock abundance since 1988 and remained closed in 1991. The St. Matthew Island blue king crab stock has improved steadily since 1986 when the abundance index reached a historical low of 0.4 million legal crab. Indices were 1.7 and 2.2 million legal crab in 1990 and 1991, as compared to 1.5 million in 1989. The St. Matthew Island stock is currently at average abundance and apparently stable.

Tanner and snow crab (*Chionocetes* spp.) abundance indices have increased steadily since the mid-1980s and, in the case of snow crab (*C. opilio*), are now at a historic high. The abundance of legal male Tanner crab (*C. bairdi*) reached a historic low in 1986, and the fishery was closed in 1986 and 1987. Abundance increased approximately tenfold, reaching 42.3 million legal males in 1989. In 1990 and 1991, abundance indices were 53.7 and 45.5 million legal crab, respectively. The snow crab stock also rebounded dramatically from historic lows in the early 1980s, showing an almost sixfold increase by 1990 when the abundance of commercial males reached 420.3 million crab. The abundance index reached 484.1 million commercial males in 1991. This fishery was of minor importance 10 years ago but is now the nation's most valuable crab fishery and will dominate in the Bering Sea in the near future.

Shrimp Research

The annual fall survey of Pavlof and Volcano Bays on the Alaska Peninsula has been conducted since 1972 and is the longest continuous time series of shrimp stock assessment in Alaska waters. The northern shrimp (*Pandalus borealis*) is the dominant

species in this area and has typically made up more than 95% of the shrimp biomass in the two bays since 1979. Biomass estimates were 380,000 pounds in 1989, 520,000 pounds in 1990, and 850,000 pounds in 1991. Although biomass estimates have increased, they remain far below the 1972-78 average of 17.8 million pounds.

Juvenile Red King Crab Survey

A 10-day survey was conducted in 1991 in Bristol Bay to find potential monitoring sites and to make observations of juvenile red king crab and selected juvenile fishes. Primary objectives were to 1) determine distribution and relative abundance of juvenile red king crab and flatfish in inshore waters that are not covered in the annual trawl survey, 2) identify microhabitats of red king crab, and 3) deploy continuous temperature recording devices in juvenile red king crab habitat. Juvenile red king crab were found at almost all of the locations. Crab in the 4- to 11-mm carapace length category were likely the 1990 year class and were found in association with mussels or with bryzoans and hydroids, which in turn were attached to stalks of sea onions (*Boltenia ovifera*). Further work on the relationships between juvenile red king crab and the hydroid/bryzoan/*Boltenia* complex is planned.

Juvenile Red King Crab Habitat Study

The first phase of a study of juvenile red king crab habitat in Kodiak waters has been completed. A report entitled "Characterization of Preferred Habitat for Juvenile Red King Crab in Three Kodiak Bays" was submitted in June 1991 to the Kodiak Island Borough which funded the research as a precursor to feasibility studies of the rehabilitation of the near-island populations. This study is the first in situ study of habitat characteristics of juvenile king crab and will be extended through 1992. More than 200 hours were spent by divers documenting significant, recurring patterns which define preferred habitats in three distinct bays. Each bay represents a different habitat and, hence, degree of suitability for juvenile red king crab. Juveniles were highly aggregated and often associated with structures that had high vertical relief. Juvenile crab were often found associated with or actually resting on the sea star, *Evasterias troschelii*. Work is continuing on migration of sonic-tagged crabs and further habitat characterization.

UNDERSEA RESEARCH PROJECTS

During April and May 1991, two undersea research projects were conducted near Kodiak using a submersible. The work was supported through the NOAA National Undersea Research Program. The 16-foot *Delta* submersible with a maximum working depth of 1,200 feet was employed. The first project explored the characteristics of mating Tanner crabs captured in situ. This was the first investigation of the reproductive biology of Tanner crabs at depths beyond those available to scuba divers. The investigation focused on multiparous females and the characteristics of males mating with them. A total of 41 dives were made and 47 males from grasping pairs were collected. The most important and surprising result of this project was the discovery

of thousands of mature crabs aggregated in a small (100 m X 300 m) area at about 150-155 m depth. Within this area, multiparous females formed evenly spaced mounds of up to 500 crabs each, around which males were concentrically arrayed at densities of 1-10/m². All underwater observations were videotaped with simultaneous voice and environmental parameter recording. A report on morphometry and maturity of males in grasping pairs has been submitted for publication.

The second project examined the effects of Kodiak fish waste disposal on benthic habitats and associated water quality. For many years, fish processing wastes have been dumped at sea in an U.S. Environmental Protection Agency permit area just beyond the 50-fathom (91-m) isobath. Dives were made in the dumpsite area and in a nearby control area where dumping has not occurred. Measurements of dissolved oxygen, pH, temperature, and salinity, as well as microbiological samples, were obtained. Flounders and hermit crabs were more abundant in the dumpsite area while pink shrimp (*Pandalus jordani*) were more abundant in the control area. Tanner crab were abundant in the dumpsite area and did not seem to be adversely affected, although results of laboratory analysis of microbiological samples of their gills are still being analyzed. Dissolved oxygen levels were generally above 80% saturation in bottom water samples. Initial conclusions are that dumping does not seem to have had an adverse impact in terms of water quality but may have affected species composition in the permit area.

RECRUITMENT PROCESSES

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.

Field Studies

FOCI conducted four cruises aboard the NOAA research vessel *Miller Freeman* during the spring of 1990 and 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 first cruise in 1990 was a survey of the distribution of the planktonic eggs of the walleye pollock that spawned in Shelikof Strait. Samples of fish and invertebrates that are potential predators on pollock eggs were also collected. Other work included an investigation of the digestion rate of pollock eggs in stomachs of adult pollock, the maturation of pollock, and stripping and culturing pollock eggs for laboratory studies in Seattle. A second cruise sampled young larvae and potential predators. The samples indicated that the larvae formed a large patch in lower Shelikof Strait. Satellite drifters released in the patch remained in the general area for several weeks but travelled in a circular pattern at about one revolution every 2 days. It appeared that the drifters were

entrained in a mesoscale eddy and that the larval patch was also associated with this feature. The following cruise sampled water properties in the vicinity of the eddy and confirmed the continued presence of larvae. Eddy boundaries and the water movement within it were determined, based on temperature and salinity measurements. At the beginning of the last spring cruise of 1990, the eddy was still present and larvae were still more abundant within it than elsewhere. During the cruise, the drifters started to move more rapidly to the southwest. Apparently the eddy then broke up and the drifter movement became more under the influence of the southwestward setting Alaska Coastal Current. Late in the cruise the larval patch was still in the area of the drifters and was displaced to the southwest of its location on the previous cruise. Data collected during these cruises will allow us to estimate larval growth, mortality, and drift rates and also permit us to compare larval food production in and out of the eddy and to evaluate whether it is advantageous, in terms of increased growth and survival rates, for the larvae to be associated with such a structure.

The FOCI program again conducted four cruises on the *Miller Freeman* in the western Gulf of Alaska in late winter/spring 1991. The first cruise was a broad-scale egg survey to examine the extent of spawning activity in areas adjacent to Shelikof Strait. The goals of the second cruise were to study finer scale aspects of the distribution and abundance of walleye pollock eggs in the major spawning area of Shelikof Strait and to deploy instruments for making measurements of ocean currents and physical properties. The last two cruises were designed to examine the biophysical interactions of pollock larvae, their predators, and prey, as well as to study the broad-scale distribution of larvae and measure their mortality.

Unusually stormy periods in 1991 will provide a unique opportunity to study the effects of extreme environmental conditions on 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. In 1991, field work concentrated on the process of offshore advection of larvae because high concentrations of larvae were not found. 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. 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.

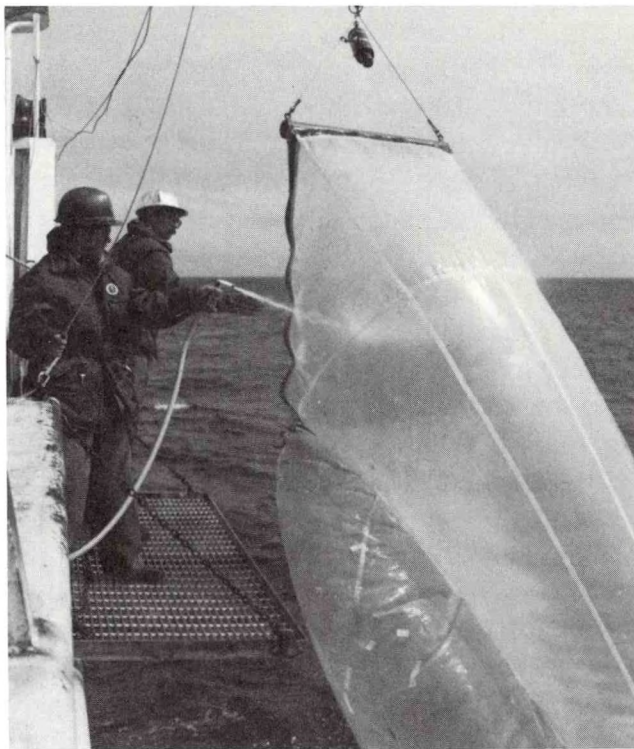
Juvenile pollock surveys were conducted by the FOCI program during both 1990 and 1991 to examine the merits of different sampling systems, to observe relative abundance and distribution, collect biological data, and to determine the identity of important predators. The 1990 cruise was a large-scale midwater trawl and hydroacoustic survey of pelagic juveniles from Kodiak to Unimak Island in the Western Gulf of Alaska. Age-0 pollock (40-120 mm) were caught in 80 of 133 hauls and were found in high abundance both inshore and on the shelf. The anchovy net appeared to catch more pollock per unit of effort and also larger pollock than the shrimp trawl. Hydroacoustic transects between trawl stations revealed much variability in the horizontal and vertical

distribution of juvenile pollock. A survey was conducted during July of 1991, but because smaller pollock were present at the time and were difficult to distinguish acoustically from other organisms in the scattering layer, no hydroacoustic data were taken. The Methot trawl was more effective at sampling the smaller juveniles present at this time of the year than either the anchovy or shrimp trawls. Higher catches were made inshore during 1991.

Laboratory Studies

In spring of both 1990 and 1991, laboratory experiments 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 (1990 and 1991) and Bogoslof Island area (1991), maintained in refrigerators aboard ship, and then transported in insulated jugs to the culture center at Sand Point. In 1991, 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 seawater and fed on a diet of rotifers. At the Friday Harbor Laboratory the larvae were raised in higher quality seawater 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 for eggs at 150-200 m in the Gulf of Alaska, while those held under constant light increased in density suggesting a mechanism for avoiding light. These differences in response to light and dark represent a novel behavioral/physiological



Scientists sample with a Tucker trawl for larval pollock in Shelikof Strait during a FOCI cruise aboard the Miller Freeman.

mechanism for regulation of depth by pelagic eggs and suggest that models of egg distribution in the sea that only account for passive dispersal may be inadequate.

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 age-0 juveniles having less affinity for this type of refuge as they move into deeper water.

FISHERIES RESOURCE PATHOBIOLOGY

Dungeness Crab Mortality

In late May of 1990, a large number of dead or dying Dungeness crabs (*Cancer magister*) were found on a private beach in northern Puget Sound, Washington. Preliminary examination of several crabs revealed the presence of an undescribed species of facultative ciliate in the blood of moribund crabs. As a result, a sampling scheme to determine the prevalence of the ciliate in Dungeness crabs at the private beach and at a public beach one and one-half miles to the south was initiated. Examination of 335 male and female Dungeness crabs revealed infection prevalences reaching 14%. In 1991, an additional 122 crabs were examined with overall infection prevalences also reaching 14%. During both sampling periods, infections were more common in recently molted male and female crabs and in hard-shell females. Infections were also diagnosed in older shelled crabs. Ciliate infections in males were generally higher at the private beach while infections in female crabs were more common at the public beach. This is the first report of a ciliate infection in a wild crustacean population and suggests that ciliate-induced mortalities are likely to occur during the molting period. The evidence indicates that death may occur approximately 2 weeks after entry of the ciliated protistan.

Bitter Crab Syndrome

Studies on the prevalence and distribution of bitter crab syndrome (BCS) in Bering Sea Tanner crabs were continued during 1990 and 1991 completing 4 years of study. The data indicate that BCS is generally more prevalent in *C. opilio* than in *C. bairdi* and is more common within the *C. opilio* species north and west of St. Matthew Island.

CONSERVATION ENGINEERING

Improving Measurements of Area-swept

Research has continued on the effects of variability in the operating dimensions of bottom trawls on survey results. Extensive use of acoustic trawl mensuration equipment, both during the surveys and in experimental work, has shown that the trawl's width and height can vary considerably within and between stations. Mensuration data have been analyzed to determine the best predictors of this variation and to evaluate its effects on survey results. A strong association has been found between trawl width and the length of cable used to tow the trawl (scope), with longer scopes associated with wider trawl openings and lower heights. Since longer scopes must be used in deeper water, trawl openings tend to be wider in the deeper areas covered by the surveys. Where direct trawl width measurements were not available, a regression based on the above work was used in calculation of the area swept.

Bycatch Research

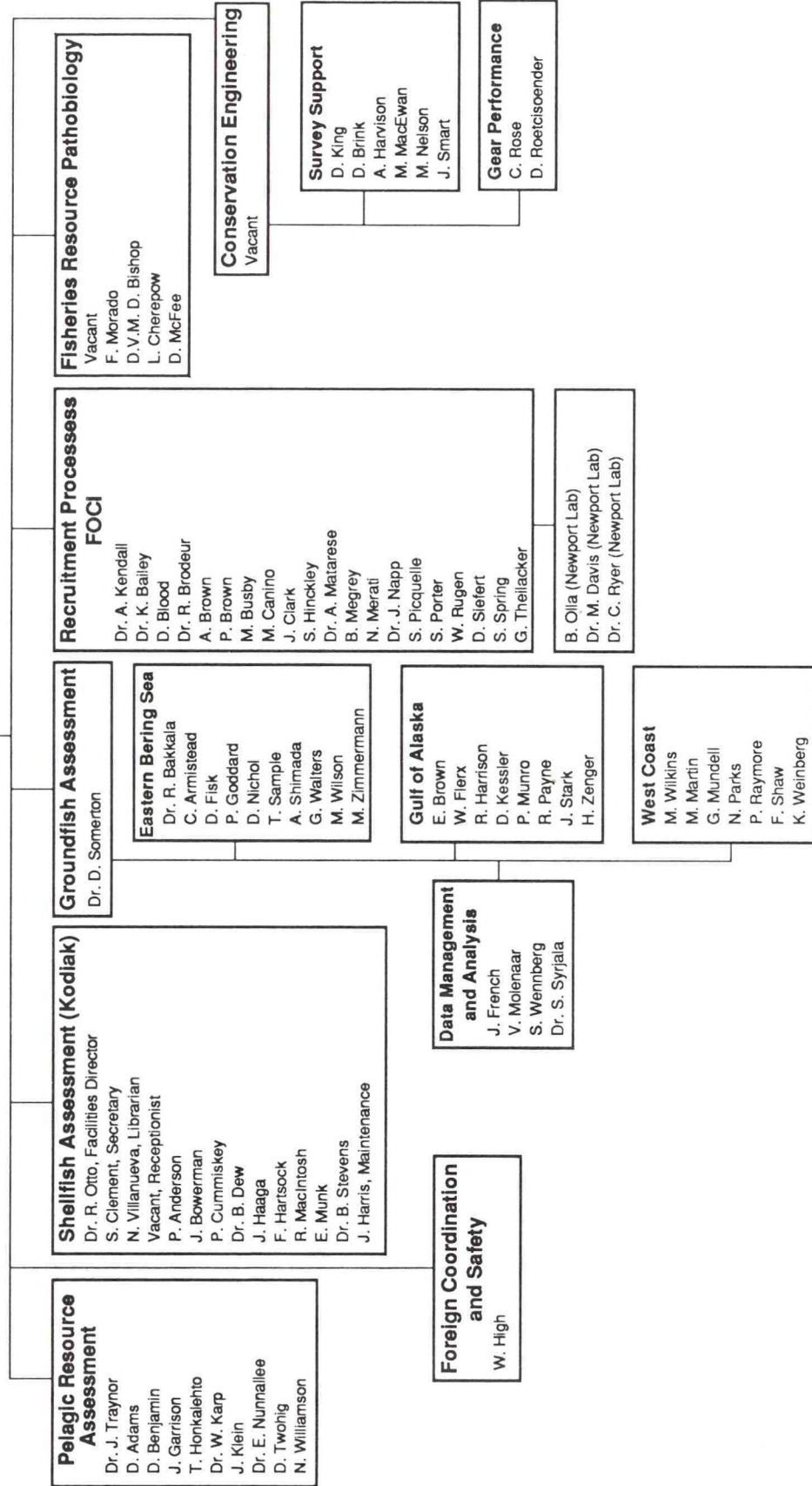
The bycatch of Pacific halibut in trawl fisheries off Alaska is a major concern to fishery managers. Bycatch limits have closed several fisheries before the allowable catch of the target species was taken. Representatives of the International Pacific Halibut Commission, the fishing and fishing gear industries, and the RACE Division have been cooperating since the spring of 1990 in a research project to develop fishing gear technology capable of both effective fishing for target species and bycatch reduction. The first objective of the study was the development of an underwater camera system to observe the behavior of Pacific halibut and co-occurring species in the vicinity of the trawl. A silicon-intensified target video camera, with resolution at light levels as low as 10^{-3} lux, was selected for this use. This sensitivity permitted observation without artificial lights, which could affect fish behavior. During two pilot cruises in 1990, the system was refined and some preliminary observations of fish behavior were made. The first full-scale study was carried out in September 1991 in the vicinity of Kodiak. Several trawl modifications, including lead lines, a mid-trawl rope grid, and roller gear configurations were used to test for differences in behavior by species and size. While numerous medium-sized halibut (50-80 cm length) and small flatfish were observed, relatively few cod or other roundfish were found. Some preliminary observations were that flatfish did not immediately pass through horizontal openings provided by the grids in the intermediate and codend. They would only pass through if they achieved a head first orientation to one of the openings. The larger halibut swam in front of the footrope for long periods (5 minutes) while small flatfish held position for less than 2 minutes using short, quick bursts. Medium-sized halibut and roundfish passed back into the net well above the bottom panel, while small flatfish tended to stay close to it. This was more apparent when the leading lines between footrope and intermediate were used. Results and the video footage will be made available to gear researchers, net manufacturers, and fishermen to encourage participation in the development of selective trawls.

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION

ORGANIZATION CHART

1990-91

Dr. G. Stauffer, Director
T. Dark, Scientific Program Manager
L. Oldham, Secretary



RESOURCE ECOLOGY AND FISHERIES MANAGEMENT (REFM) DIVISION

The REFM Division conducts research on the ecology, status, bio-economics and management of fisheries resources off Alaska and the Pacific Coast. Scientists from the Division also provide technical liaison between research and the fisheries management process.

FISHERIES OBSERVER PROGRAM

During 1990-1991, the Observer Program at the AFSC was responsible for three separate observer programs: a foreign/joint venture observer program, a domestic groundfish observer program, and a high-seas driftnet fisheries observer program.

Foreign/Joint Venture Observer Program

The year 1990 was the 14th and last year that foreign and joint venture fisheries operated under the Magnuson Fisheries Conservation and Management Act in the Northeastern Pacific Ocean and Bering Sea. The program deployed 72 observers aboard 65 different foreign/joint venture vessels in the Bering Sea and 36 observers aboard 34 different foreign/joint venture vessels off the coasts of Washington, Oregon, and California. Japan, Republic of Korea, U.S.S.R., Poland, and the People's Republic of China participated in these joint ventures. Observers covered 83% of the foreign/joint venture fishing effort in the Bering Sea and 96% of the foreign/joint venture effort off the coasts of Washington, Oregon, and California.

Domestic Groundfish Observer Program

The year 1990 was the first year of mandatory observer coverage for domestic groundfish fisheries off Alaska. Scientific observers were placed on domestic vessels and at shoreside processing facilities. Some observers were also voluntarily placed aboard domestic vessels fishing off the coasts of Washington, Oregon, and California. The observers collect data for in-season monitoring of prohibited species bycatch levels and for evaluating and developing long-term fisheries management strategies. They also play an important role in monitoring compliance to fishing regulations.

During 1990 and 1991, the program deployed 1,212 observers on 363 different vessels and 32 different shoreside plants. Under the mandatory program for Alaska, observers provided nearly 100% coverage on vessels greater than 125 ft in length and about 30% coverage on vessels between 60 and 124 ft in length. They also provided nearly 100% coverage to shoreside plants that process more than 1,000 metric tons (t) of groundfish per month and about 30% coverage to shoreside plants that process between 500 and 1,000 t of groundfish monthly.

The Domestic Groundfish Observer Program operates as a combination of shared efforts and responsibilities among the NMFS, the fishing industry, and independent

observer contractors. The NMFS has operational responsibility for the overall administration of the program as well as defining the sampling duties and data collection methods used by observers, training observers prior to deployment, debriefing observers upon their return, and editing and managing the resulting data. The fishing industry is responsible for making arrangements with observer contractors to provide NMFS-certified observers and for paying for the direct costs of placing observers aboard vessels or at processing facilities. The observer contractors certified by the NMFS to provide observer services are responsible for the recruiting and deployment of observers, observer logistics, insurance and employee benefits, and delivery of observer data to the NMFS.

High-Seas Driftnet Fisheries Observer Program

During 1990-91, five driftnet fisheries occurred in the North Pacific Ocean: Japan, Korea, and Taiwan target on squid; Japan and Taiwan also target on tuna and billfish. Gear type, as well as time and areas fished, differ among these five fisheries. Concern over the potential impacts of these fisheries which involve approximately 700 vessels that collectively set and retrieve between 55 and 80 million 50-m net panels annually, led to the Driftnet Impacts Monitoring, Assessment, and Control Act of 1987. This act provided the legislative impetus for negotiated agreements between nations to develop scientific monitoring programs, which were fully implemented with each nation in 1990. The United States was involved in each of these programs (Japan-Canada-United States, Republic of Korea-United States, and Taiwan-United States). Observers from each nation were deployed to host vessels to gather data on bycatch rates and biological information so that assessments could be made of driftnet impacts upon the living marine resources of the North Pacific ecosystem. This information was to be used also by parties to the United Nations (UN) in addressing the directives of UN resolution 44/225 calling for a moratorium of all high-seas driftnetting by June 1992.

This was an interdivisional as well as interagency program requiring close cooperation between the REFM Observer Program, the Auke Bay and National Marine Mammal Laboratories, the Honolulu Laboratory of the Southwest Fisheries Science Center, and the U.S. Fish & Wildlife Service-Anchorage. In addition, observer duties and sampling protocols were established in cooperation with the Canadian Department of Fisheries and Oceans Pacific Biological Station, Nanaimo,



Members of the U.S. Fisheries Observer Program prepare to sample a midwater trawl catch.

B.C., and through meetings and correspondence with representatives of the Japanese, Korean, and Taiwanese programs.

The REFM observer program was responsible for the observer training, deployment, debriefing, and data quality control facets of the U.S. observers, as well as assisting foreign programs with the development of their observer programs. Observers monitor driftnet retrievals to record 1) the amount of gear monitored; 2) date, time, and location of the sets; and 3) the associated numbers of animals, by species, of the catch and bycatch. Observers also collect biological information from representative samples of those animals incidentally taken. These data are used to develop catch per unit effort information on a time and area basis and to assist in the assessment of impacts upon stocks, populations, and species. Driftnet observers were not involved in monitoring for enforcement of compliance to the domestic regulations of each nation.

During the 1990-91 season, U.S. observers made 58 of the 119 observed cruises in the five fisheries monitored. During the 1991 season, four fisheries were monitored with U.S. observer participation accounting for 48 of 103 observed cruises. REFM observer program staff provide information on data collected by U.S. observers during international scientific review meetings held to agree upon common data files to be used for driftnet impact assessments.

All three nations have agreed to end their driftnet fisheries by the end of 1992. Observers will probably not be deployed during this final season.

AGE AND GROWTH STUDIES

The primary responsibility of the Age and Growth Studies Task is to age fish. This is achieved by counting the annual growth rings on otoliths, scales, and fin-rays. The task must also establish ageing criteria for new species and examine problem areas where the generated ages appear unsatisfactory. Data from the Age and Growth Task are used to model fish population dynamics. These results are in turn used for fishery management. Currently the task is active in ageing walleye pollock (*Theragra chalcogramma*), Pacific whiting (*Merluccius productus*), Atka mackerel (*Pleurogrammus monopterygius*), sablefish (*Anoplopoma fimbria*), yellowfin sole (*Pleuronectes asper*), Alaska plaice (*P. quadrituberculatus*), rock sole (*P. bilineatus*), flathead sole (*Hippoglossoides elassodon*), Pacific cod (*Gadus macrocephalus*), Pacific ocean perch (*Sebastes alutus*), and rougheye rockfish (*S. aleutianus*). Total ages read for 1990 and 1991 are as follows:

Age Category

Year	Raw	Test	Re-aged	Unageable	Totals
1990	31,523	6,430	3,577	697	42,227
1991	23,656	6,832	3,855	678	35,021

A Committee of Age Reading Experts (CARE) Conference was held during 16-18 May 1990 at the AFSC. Scientists from the Division demonstrated techniques currently being used to age pollock. The meeting considered the use of precision data, reader training, the use of reference collections, and flatfish ageing.

An international workshop on the ageing of walleye pollock was held in Gdynia, Poland, 10-14 September 1990. The meeting attendants agreed that broken and burnt otoliths at this time appear to be the best available method to age this species.

STATUS OF STOCKS AND MULTISPECIES ASSESSMENTS

Alaska Fisheries

During 1990 and 1991, the Status of Stocks Task assessed the condition of fisheries resources and strategies for their management. Groundfish research was conducted on commercially important stocks in the Bering Sea, Aleutian Islands, and the Gulf of Alaska. Research included analysis of population dynamics, evaluation of management strategies, estimation of potential yields, and the continuing development of new assessment techniques and data sources. Task members continued assessments of walleye pollock, Pacific cod, yellowfin sole, sablefish, Pacific ocean perch, other commercially important rockfish and flatfish, thornyheads (*Sebastolobus* spp.), and Atka mackerel. In addition, two task members served on groundfish management teams for the North Pacific Fishery Management Council (NPFMC). Other research included Pacific herring (*Clupea pallasii*) early life history and recruitment variation relative to eastern Bering Sea oceanographic factors, analysis of the 1990 Bering Sea and Gulf of Alaska fishery data to discern Pacific halibut (*Hippoglossus stenolepis*) discard mortality, and analysis of decadal variations in winter ocean conditions relative to the recruitment success of northeast Pacific Ocean groundfish.

Status of Stocks Task members participated in development and implementation of a comprehensive working plan to improve rockfish (*Sebastes* spp.) stock assessments and management recommendations. The focus of the plan is to identify, to develop, and to prioritize specific rockfish research activities. The plan proposes a number of research approaches designed to improve estimates of exploitable rockfish biomass or generate optimal exploitation rates.

The AFSC hosted two multi-national workshops directed toward a Bering Sea-wide assessment of walleye pollock. The workshops were attended by scientists from Canada, China, Japan, Korea, Poland, and Russia. The first workshop, held in February 1991, focused on database development and the structuring of Bering Sea-wide pollock assessment models. The second workshop was held in February 1992 to examine model performance under different assumptions and model tuning criteria. The results obtained during the modelling workshop showed a pollock biomass in the Bering Sea that was lower than previously estimated and more comparable to survey estimates. Future workshops are planned to refine the models and estimates.

Refinement of the OSCURS (Ocean Surface Current Simulations) numerical model, a tool developed in the Ecosystem Modeling Task for describing ocean variability, continued through 1991. It is now used by the Status of Stocks Task to investigate oceanographic and atmospheric indices to improve the understanding of changes in fish stocks. Recently the model was used to simulate trajectories of sockeye salmon (*Oncorhynchus nerka*) during the ocean migration phase of their return to the Fraser River. Further calibrations of the model are planned with satellite-tracked drifters from the Northeast Pacific Ocean and Bering Sea.

As part of its bycatch management program, the Task initiated development (with Pentec Technologies, Edmonds, WA) of an ultrasonic tag and tracking system to assess the viability of individual trawl-caught and released Pacific halibut. The system developed for the study will enable the estimation of survival probability for incidentally caught and released Pacific halibut.

Marine mammal and fishery interactions are an increasingly important issue in the management of groundfish fisheries off Alaska. The listing of the Steller sea lion (*Eumetopias jubatus*) as threatened under the Endangered Species Act in 1990 has placed considerable focus on this issue. Members of the Task have worked closely with scientists from the NMML and other institutions in exploring the possible role of groundfish fisheries in the sea lion decline and provided management recommendations for the fisheries given the present status of three declining pinniped populations. Task members also provided information, data, and advice regarding marine mammal/fishery interactions in the groundfish fisheries in preparation of the Draft Legislative Environmental Impact Statement for the Proposed Regime to Govern Interactions Between Marine Mammals and Commercial Fishing Operations scheduled for submission to Congress in 1992.

In 1989, NOAA published the *602 Guidelines*, which serves as the agency's official interpretation of the Magnuson Fishery Conservation and Management Act, and required the Fishery Management Councils to establish definitions of overfishing for the fisheries under their respective jurisdictions. The Task took the lead in developing, analyzing, and justifying alternative overfishing definitions for the groundfish fisheries managed by the NPFMC and the Pacific Fishery Management Council (PFMC). The final product was a hierarchical system in which the amount of data available for a particular species determines the type of overfishing definition to which its respective fishery is subject.

In 1990, the NPFMC addressed the issue of pollock utilization in the groundfish fisheries off Alaska. Task members provided a biological assessment of the impacts of pollock roe-stripping. Roe-stripping is defined as the taking of roe from female pollock and the subsequent discard of the remainder of the female carcass and all male pollock. The research that had been conducted had not established that there were significant adverse biological impacts under the status quo in which roe fisheries were occurring.

The NPFMC is currently addressing a resource allocation problem of preemption of shoreside processing plants by at-sea processors in the pollock and Pacific cod fisheries off Alaska. Task members participated in drafting the Supplemental Environmental Impact Statement for a proposed amendment to the Fishery Management Plans of the Gulf of Alaska and The Bering Sea/Aleutian Islands. The biological analysis indicated that as long as the fisheries are managed within their respective quotas, the proposed allocation schemes should have minor impacts on the resources. There are, however, potential impacts upon the related marine ecosystem, including marine mammals, seabirds, and the coastal environment. Changes in fishing areas and intensity as a result of direct allocations are possible, and shifts in fishing or processing activity could influence bycatch of other species.

Pacific Coast Fisheries

Task members had the lead role for West Coast stock assessments of Pacific whiting, Dover sole (*Microstomus pacificus*), and sablefish. They provided technical support to Pacific Coast fishery managers and conducted research designed to improve the accuracy of the annual stock assessments.

A Task member served as Chairman of the Groundfish Management Team (GMT) for the PFMC. The GMT contributed to a number of substantial reviews during 1990 and 1991. Task members assisted in analysis of amendments which established a procedure for initiating regulatory change without a plan amendment, defined overfishing to safeguard the stocks' productivity, and initiated development of a license limitation program. They also assisted in the review of season opening dates for sablefish and Pacific whiting and bycatch in the Pacific whiting fishery. In addition, groundfish trip limits were modified to maintain an orderly, year-round fishery without inducing unreasonable amounts of discard.

Task members participated in the U.S.-Canada Pacific whiting working group. The working group brings together AFSC scientists active in Pacific whiting research with Canadian scientists from the Department of Fisheries and Oceans. In meetings during 1990 and 1991, important topics included planning for the 1992 NMFS and Canadian acoustic surveys, review of Pacific whiting stock assessment, and developing new population modeling techniques. In 1991, as U.S. and Canadian managers began to deal with the question of binational allocation of the Pacific whiting resource, the working group provided scientific analyses of proposed allocation methods to the U.S. and Canadian negotiators.

The Task continues to work on improving user access to the Stock Synthesis model for fishery stock assessments. This model is currently used to assess the Gulf of Alaska pollock resource; the Bering Sea/Aleutian Islands Atka mackerel, Pacific ocean perch, yellowfin sole, and rock sole resources; and the West Coast Pacific whiting, Dover sole, and sablefish resources. A user's manual has been written and a 2-day workshop was conducted for NMFS stock assessment scientists.

RESOURCE ECOLOGY AND ECOSYSTEMS MODELING

Trophic Interactions Studies

The Trophic Interactions Program continued regular monthly observer training for collection of food habits information on key groundfish in the North Pacific. In addition, program personnel collected fish stomach samples during resource assessment surveys in the eastern Bering Sea, Gulf of Alaska, Aleutian Islands, and off the Washington-Oregon-California coast.

In 1990, totals of 10,028 and 4,480 stomachs were collected in the eastern Bering Sea and Gulf of Alaska, respectively. Collections totalled 9,563 in the eastern Bering Sea, 2,647 in the Aleutian Islands region, and 847 off the West Coast during 1991. Shipboard scans of stomach contents were taken by observers, totalling 2,151 and 1,001 for 1990 and 1991, respectively. Contents of 8,061 and 7,072 stomachs were analyzed in the laboratory during the 2 years.

The program provided food habits information and analysis. An analysis of geographic differences in Pacific whiting diet was performed for University of Washington researchers interested in determining whether such differences might explain geographic differences in myxosporidian parasite infections of Pacific whiting. Diet information on several groundfish species in the eastern Bering Sea was given to University of Alaska researchers analyzing Bering Sea food webs. Collection and prey identification techniques were taught to University of Washington students and staff.

Research conducted in 1990-91 included completion of a flathead sole food habits study; an analysis of walleye pollock cannibalism versus water column stratification; an analysis of size, abundance, and location of juvenile Tanner crab (*Chionocetes*) consumed by groundfish; a comprehensive summary of consumption of important prey by groundfish predator populations for 1984 to 1986; and a summary of walleye pollock and Pacific herring consumption by groundfish predator populations from 1985 to 1988. Research emphasis continues to be on interannual changes in groundfish predation on commercially important prey and comparisons with removals by marine mammals, birds, and the commercial fishery.

Ecosystem Modeling

In cooperation with Norwegian scientists, fish ecosystem simulation has been adapted for the Barents Sea. This simulation is used for resource assessment in determining carrying capacity and the factors controlling it, and for investigation of causes for the big changes which have occurred in this region in the late 1980s.

The present state of knowledge of the effects of weather and climatic changes on fisheries and on ocean resources has been reviewed and summarized in a book in press.

SOCIOECONOMIC ASSESSMENTS

The Socioeconomic Task provided economic information and assistance to the PFMC and NPFMC, industry, NMFS, and other agencies. This included preparing reports and publications, participating on Council plan teams in preparing draft regulatory impact reviews of Bering Sea/Aleutian Islands, Gulf of Alaska, and Pacific Coast groundfish fishery management plan amendments, and preparing and reviewing research proposals and programs.

Task members provided major contributions to the groundfish management plan amendments and updated and revised the West Coast groundfish plan. The major issues included the bycatch problem in the groundfish fishery, inshore/offshore groundfish allocation in fisheries off Alaska and the Pacific Coast, and limited entry in the Pacific halibut and sablefish fisheries and in the West Coast groundfish fishery. They were instrumental in implementing a coordinated data collection program for the domestic fisheries off Alaska.

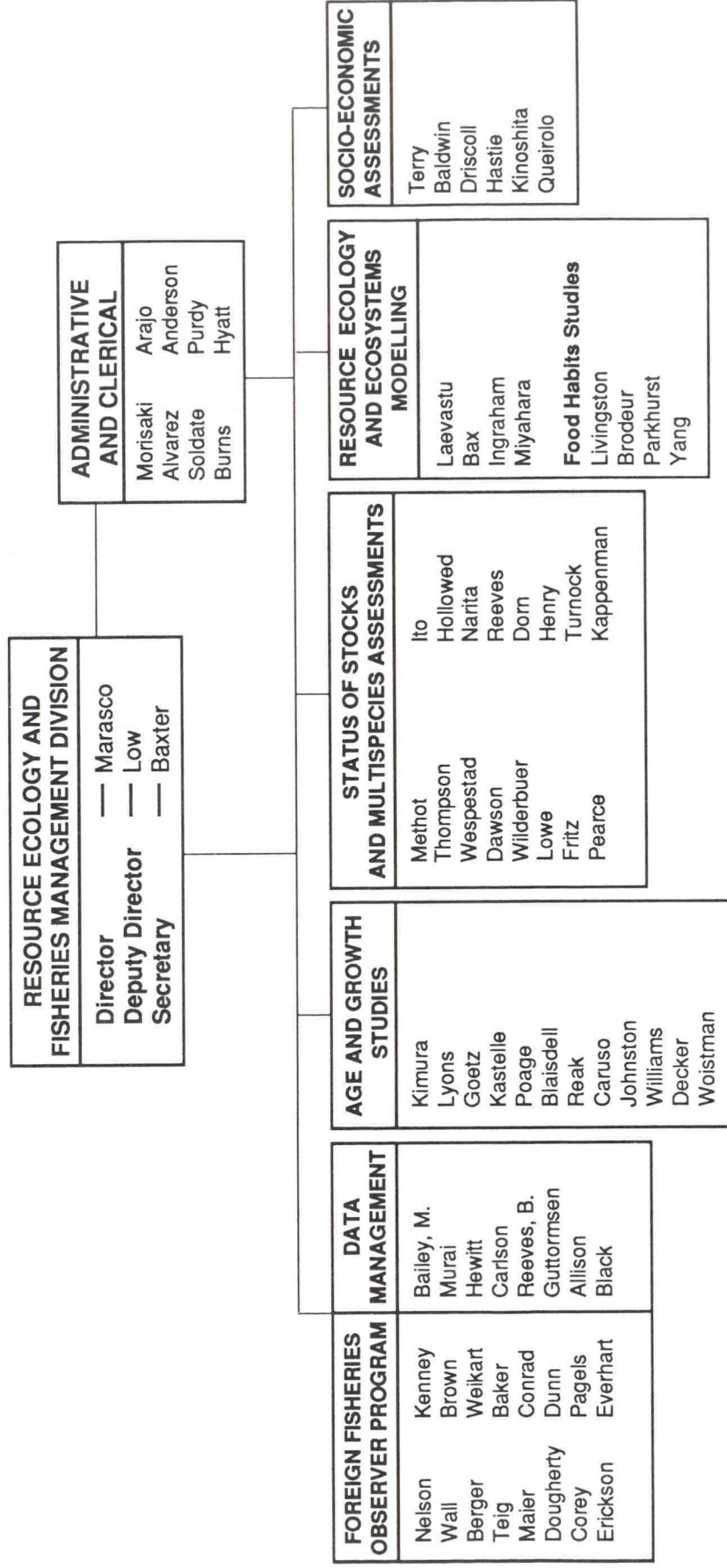
Task members contributed to the development of studies to evaluate economic effects of the *Exxon Valdez* oil spill in Prince William Sound, developed criteria for assessing the costs and benefits of alternative oil spill restoration projects, contributed to the preparation of regulatory language and supporting analysis for the Oil Pollution Act of 1990, reviewed protected species management plans, and provided database extracts for research projects conducted by others.

The reports and publications presented the results of research concerning the development of bioeconomic models for sablefish; fishery product exports from Oregon, Washington, and Alaska; implications of the bycatch limits on groundfish fisheries; and draft report that served as the economic component of the stock assessment and fishery evaluation for the Gulf of Alaska and Bering Sea/Aleutian Islands groundfish fisheries. NMFS funded projects on modeling dynamic fish populations and price models for king crab.

TECHNICAL LIAISON

The staff of the REFM Division serve as scientific liaison and key technical advisors to the International Pacific Salmon Commission, the International North Pacific Fisheries Commission, the International Pacific Halibut Commission, the NPFMC, and the PFMC.

RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION ORGANIZATION CHART 1990-91



SPECIAL ITEMS CONCERNING AFSC STAFF

AWARDS AND HONORS

The NMML received a U. S. Department of Commerce, NOAA Unit Citation Award in 1990 for its rapid response and outstanding contributions to investigating the *Exxon Valdez* oil spill in Prince William Sound in 1989.

Lewis Queirolo (REFM) received the U.S. Department of Commerce, NOAA Certificate of Recognition "For outstanding contributions as a NOAA employee serving the public trust in response to the *Exxon Valdez* oil spill disaster."

Charles Guthrie, Sharon Hawkins, Christine Kondzela, Adam Moles, Claire Noll, and Charles Russell (ABL) received a U.S. Department of Commerce (NOAA) Certificate of Recognition in 1991 for their work as a group in using genetics and parasites to identify species and stocks of salmon confiscated from illegal fishing activities on the high seas.

John Helle (ABL) was elected National President of the American Institute of Fishery Research Biologists (AIFRB) for the 1990-92 term.

K Koski (ABL) received a Plaque of Recognition for his dedicated service to the Alaska Department of Fish and Game Habitat Division during 1990.

Michael Sigler (ABL) was awarded the Floyd E. Ellis Memorial Scholarship by the University of Washington, School of Fisheries.

Art Kendall and Ann Matarese (REFM) received the Outstanding Paper award in *Marine Fisheries Review* for 1987 for their contribution "Biology of eggs, larvae, and epipelagic juveniles of sablefish, *Anoplopoma fimbria*, in relation to their potential use in management."

Mei-Sun Yang and Pat Livingston (REFM) received Honorable Mention Recognition in *Fishery Bulletin* for their paper, "Food habits and daily ration of Greenland halibut, *Reinhardtius hippoglossoides*, in the eastern Bering Sea."

Robert Pacunski's (REFM) paper, "Food Habits of Flathead Sole, *Hippoglossoides elassodon*, in the Eastern Bering Sea," was nominated for best student paper (Western Division) at the 1991 American Fisheries Society meeting.

ADVANCED DEGREES

Jason Baker (NMML) received a Master of Science degree from the University of Washington, College of Forest Resources.

Carter Braxton Dew (RACE) received a Ph.D. in Biology from the City University of New York.

Martin Dorn (REFM) received a Master of Science degree from the University of Washington's Biostatistics Department.

Michael Dueker (REFM) received a Ph.D. in Economics from the University of Washington.

Anne Hollowed (REFM) received a Ph.D. in Fisheries from the University of Washington, School of Fisheries.

Craig Kestelle (REFM) received a Master of Science degree in Fisheries from the University of Washington, School of Fisheries.

Sandra Lowe (REFM) received a Master of Science degree in Fisheries from the University of Washington, School of Fisheries.

Vidar Wespestad (REFM) received a Ph.D. in Fisheries from the University of Washington, School of Fisheries.

Rosemary Rumbaugh (ABL) received a Master of Science degree in Experimental Statistics from New Mexico State University.

Robert S. Stone (ABL) received a Master of Science degree in Fisheries from the University of Alaska Fairbanks.

AFSC STAFF DETAILED TO OTHER LABORATORIES AND PERSONNEL DETAILED TO THE AFSC

Jason Baker (NMML) spent 2 weeks at the Koltzov Institute for Developmental Biology, U.S.S.R. Academy of Sciences in Moscow to study and teach others about the microstructure of pinniped teeth and its biological significance.

Malin Babcock (ABL) was detailed to the NOAA General Counsel's Office in Rockville, MD, where she worked with the oil spill Damage Assessment Regulations Team in drafting regulations under the Oil Spill Pollution Act of 1990 (OPA 90).

Jonathan Heifetz (ABL) and Michael Sigler (ABL) were detailed to Sand Point, WA, to enable them to take courses at the University of Washington under the NOAA 20/20 Training Program.

Ellen Varosi (ABL) was detailed to the NMFS Alaska Regional Office to assist in managing the sablefish hook-and-line fishery in the Gulf of Alaska and to maintain the U.S. fishery statistics pertaining to the Alaska Region, as well as to assist in managing the joint venture fishery in the Bering Sea.

Dr. Tony Gharrett, of the University of Alaska Southeast, continued to serve at the ABL as leader of genetic stock identification studies for the U.S.-Canada Salmon program under an Intergovernmental Personnel Act (IPA) agreement.

Dr. Oleg Katugin and Eugeni Matsak, geneticists from TINRO in Vladivostok, Russia, worked with staff at the ABL on cooperative genetic studies of Russian salmon.

Dr. Natalaya Varnavskaya, a geneticist from Petropavlovsk, Kamchatka, spent 6 weeks at the ABL working on cooperative genetic studies.

Table 1.--Full-time permanent individuals who retired from the Alaska Fisheries Science Center during the calendar years 1990-91.

Name	Division/Laboratory	Retirement date
Jean R. Dunn	RACE	11-30-90
Janet N. Holbrook	CD	04-30-90
Benjamin F. Jones	CD	11-30-90
Robert R. Simpson	ABL	05-03-90
Richard G. Bakkala	RACE	12-31-91
Albert K. Sparks	RACE	01-31-91
Hiroshi Kajimura	NMML	12-17-91

ABL = Auke Bay Laboratory.

CD = Office of the Science and Research Director.

NMML = National Marine Mammal Laboratory.

RACE = Resource Assessment and Conservation Engineering Division.

PUBLICATIONS AND REPORTS

1990 PUBLICATIONS

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