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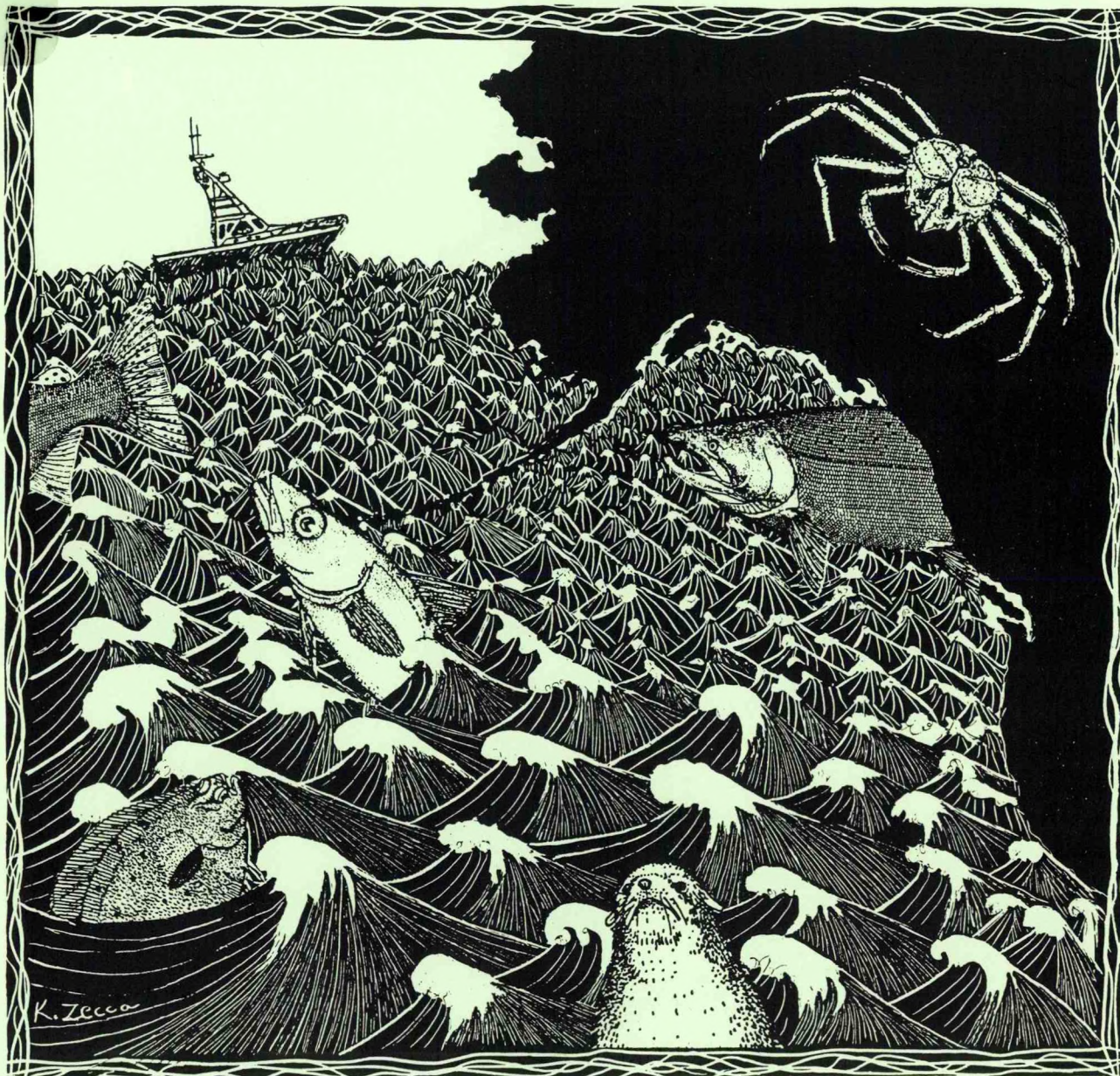


Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S. DEPARTMENT OF COMMERCE

Biennial Report for Calendar Years 1992-93



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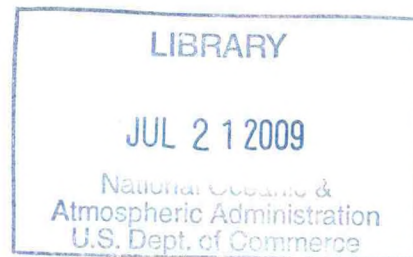
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ALASKA FISHERIES SCIENCE CENTER

Seattle, Washington

BIENNIAL REPORT 1992-93



Compiled by
Publications Unit
Alaska Fisheries Science Center
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Seattle, Washington 98115-0070

June 1995

CONTENTS

ALASKA FISHERIES SCIENCE CENTER.....	1
MARINE ENTANGLEMENT RESEARCH PROGRAM.....	3
Education and Public Awareness Projects...Mitigation Projects...Impacts Research and Monitoring Projects	
OFFICE OF FISHERIES INFORMATION SYSTEMS.....	6
PUBLICATIONS UNIT.....	6
AUKE BAY LABORATORY	9
Salmon Enhancement and Marine Recruitment Studies...U.S./Canada Pacific Salmon Treaty Studies...Marine Fisheries Assessment... Habitat Research and Protection	
NATIONAL MARINE MAMMAL LABORATORY	23
Antarctic Ecosystem Program...Arctic Ecosystem Program...Alaska Ecosystem Program...California Current Ecosystem Program...Population and Ecosystem Assessment Program...U.S.-Russia Marine Mammal Projects	
RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION.....	43
Groundfish Assessment...Midwater Assessment and Conservation Engineering...Shellfish Research...Recruitment Processes...Fisheries Resource Pathobiology	
RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION	61
Fisheries Observer Program...Age and Growth Studies...Status of Stocks and Multispecies Assessments...Socioeconomic Assessments... Technical Liaison	
AWARDS AND HONORS	71
ADVANCED DEGREES	72
PUBLICATIONS AND REPORTS.....	73
1992 Publications...1992 Processed Reports...1993 Publications...1993 Processed Reports	

ALASKA FISHERIES SCIENCE CENTER

THE ALASKA FISHERIES SCIENCE CENTER (AFSC) is the research branch of the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA-NMFS) responsible for Federal fisheries research in the coastal oceans off Alaska and the West Coast of the United States. These waters, including the North Pacific Ocean and the eastern Bering Sea, support some of the most important commercial fisheries in the world—walleye pollock, Pacific salmon, Pacific cod, sablefish, and king and Tanner crabs. These waters are also home to at least 42 species of whales, dolphins, porpoises, seals, and sea lions.

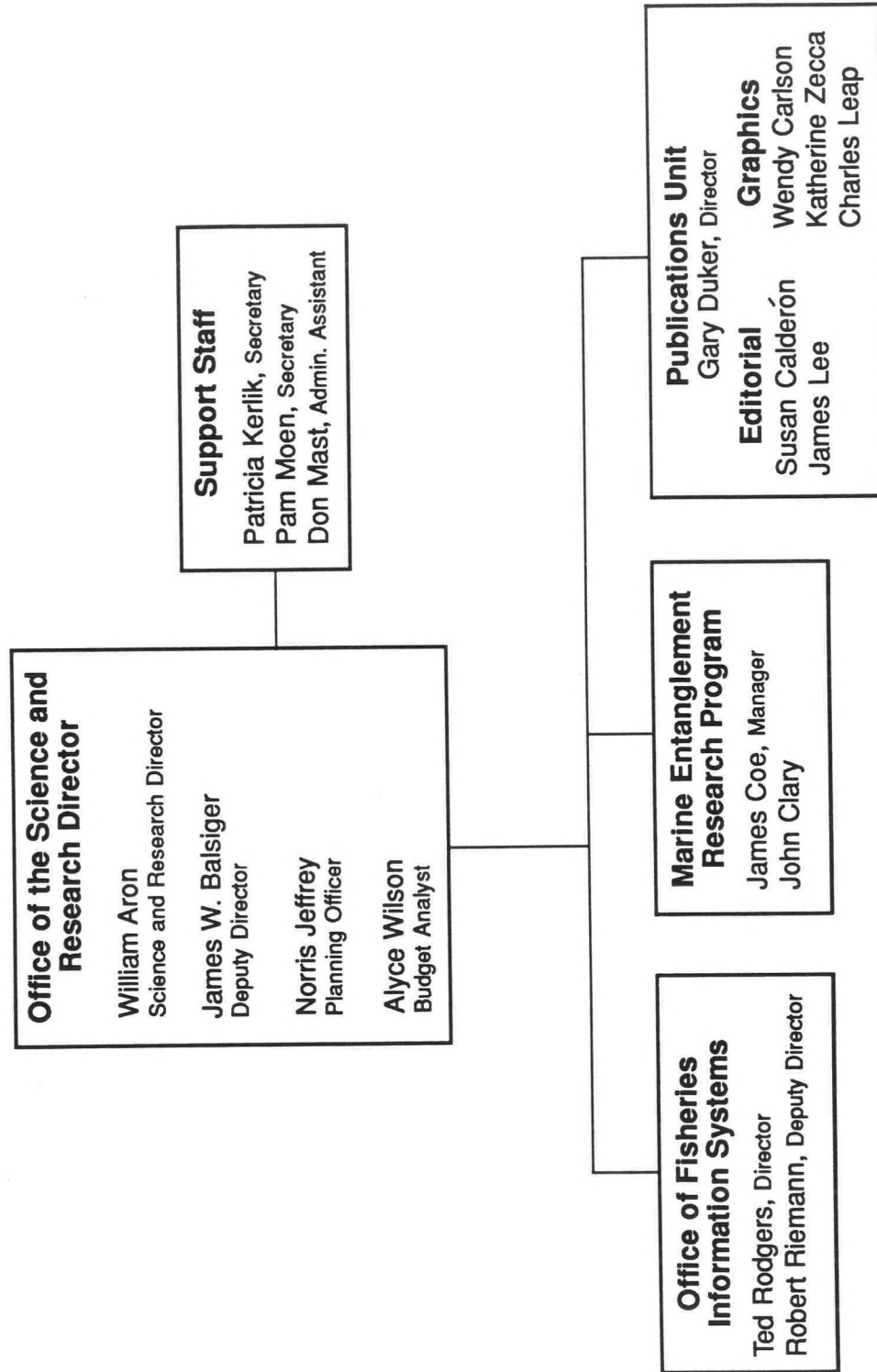
The AFSC conducts research to help conserve and manage the region's fishery resources, which provide approximately 65% of the volume and 50% of the value of the total U.S. domestic catch in the Nation's 200-mile Exclusive Economic Zone (EEZ). The Center is also responsible for monitoring the region's marine mammal populations and protecting those that are considered at risk of extinction. With this stewardship, the AFSC staff plans, develops, and manages scientific research programs designed to generate the best scientific data available for understanding, managing, and conserving the region's living marine resources and the environmental quality essential for their existence.

The primary responsibilities of the Center are to provide scientific data and technical advice to the Pacific and North Pacific Fishery Management Councils, the NMFS Alaska Regional Office, U.S. representatives participating in international fishery and marine mammal negotiations, and the fishing industry and its constituents. The Center also coordinates fisheries and marine mammal research with other Federal and state agencies, academic institutions, and foreign nations.

The AFSC is made up of the Auke Bay Laboratory, the National Marine Mammal Laboratory, the Resource Assessment and Conservation Engineering Division, and the Resource Ecology and Fisheries Management Division. Overall leadership and administrative control for the full range of activities within the AFSC are provided by the Center's Science Director's Office, which includes the Marine Entanglement Research Program, the Office of Fisheries Information Systems, the Publications/Graphics Unit, and other support services. Program objectives are carried out at NOAA's Sand Point facilities in Seattle, Washington, at the Auke Bay Laboratory in Juneau, Alaska, and at smaller field stations in Kodiak and Little Port Walter, Alaska, and in Newport, Oregon.

This biennial report describes the AFSC's major research activities during 1992 and 1993.

CENTER DIRECTOR'S OFFICE ORGANIZATION CHART 1992-1993



MARINE ENTANGLEMENT RESEARCH PROGRAM

Projects funded by the NMFS Marine Entanglement Research Program (MERP) in 1992 and 1993 addressed the issue of marine debris (persistent solid waste pollution) as required by the Program's authorizing language and by the Marine Plastic Pollution Research and Control Act of 1987 (MPPRCA). The MPPRCA implemented in the United States Annex V, Regulations for the Prevention of Pollution by Garbage from Ships of the International Convention for the Prevention of Pollution from Ships (MARPOL V).

Education and Public Awareness Projects

Public education continued to be a major focus of the MERP. To meet this responsibility a new 5-year contract was awarded in 1992 to the Center for Marine Conservation (CMC) to continue to operate Marine Debris Information Offices (MDIOs). These offices have been overwhelmingly successful at providing to the public educational and resource materials such as printed information, posters, photographs, and video tapes relating to marine debris issues. During 1992 and 1993, the MDIOs responded to thousands of requests for information and distributed nearly 500,000 brochures and other materials.

Other education and public awareness projects funded by MERP during 1992 and 1993 included continuing work in the Pacific Islands with the University of Hawaii Sea Grant Program and initiating a marine debris outreach campaign in the Caribbean region, in cooperation with the Caribbean Subcommission of the Intergovernmental Oceanographic Commission (IOCARIBE). This latter project was undertaken to help pave the way for MARPOL V Special Area designation of the Wider Caribbean Region (which includes the Gulf of Mexico) and included MERP support, planning, assistance, and attendance of the Second Caribbean Marine Debris Workshop in Merida, Mexico. The MERP also began planning the Third International Conference on Marine Debris and provided funds for contracting a conference coordinator.

Mitigation Projects

During 1992 and 1993, two continuing projects were supported to directly reduce the marine debris problem: the National Beach Cleanup Campaign and Debris Removal from Hawaiian Monk Seal Beaches.

The National Beach Cleanup Campaign is cofunded with the Environmental Protection Agency (EPA). During the 1992 cleanup, 132,705 citizen volunteers removed 2.7 million pounds of debris from 4,500 miles of the U.S. coastline. In 1993, 158,000 volunteers collected 3.2 million pounds of debris from 4,500 miles of the U.S. coastline.

The Hawaiian monk seal project is funded by MERP through the NMFS Southwest Fisheries Science Center. Research teams working to understand and to protect the endangered monk seals made annual trips to hauling and pupping beaches in the northwest Hawaiian Islands to gather, catalog, and destroy entangling material (approximately 12,000 lb per year) that had washed ashore in this critical habitat. Since researchers began systematically documenting monk seal entanglements in 1982, 97 entanglements resulting in 19 injuries and 5 fatalities have been recorded.

Revision of the Port Reception Facility Section of the International Maritime Organization Guidelines for the Implementation of MARPOL Annex V continued through 1993. This work was done under contract and in cooperation the U.S. Coast Guard (USCG).

Projects initiated in 1992 and continued through 1993 include a project by the National Research Council's Marine Board to determine the level of compliance with MARPOL V in the United States. Funding for this study was provided by MERP, the EPA, USCG, U.S. Navy, and the Maritime Administration. MERP also set aside funds to support international ratification and implementation of Annex V.

A new project undertaken by MERP in 1993 utilized the Sea Grant network to develop marina pollution prevention plans. This project, conducted in cooperation with the International Marina Institute and the New Jersey Marine Science Consortium, gave rise to the National Ocean Marina Program.

Impacts Research and Monitoring Projects

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

Using methodologies developed in the Alaska surveys, MERP established a national survey system in 1989 in cooperation with the National Park Service (NPS). Under the program, marine debris accumulations

Six-pack rings discarded by thoughtless boaters and picnickers are a frequent form of entanglement for ducks and seabirds. The good news is that survey counts indicate that entanglement rates may be declining.



at sites in nine National Seashores have been surveyed quarterly. These sites are located throughout the East, West, and Gulf Coasts and in the U.S. Virgin Islands. The data collected will be used to characterize the marine debris problem within each region and to detect changes in the composition and amounts of debris over time. The year 1993 was the final year of the cooperative program.

Researchers at the University of Florida continued to study the effects of persistent marine debris on juvenile, pelagic loggerhead 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.

Data collection by fisheries observers in the AFSC's Resource Ecology and Fisheries Management (REFM) Division continued in 1992 and 1993. Observers placed aboard U.S. fishing vessels operating in the North Pacific Ocean collected marine debris data in addition to their normal observer duties. Observer data are used to characterize type, amounts, and distribution of marine debris and debris generated by fishing vessels.

Two new programs initiated in 1993 are the National Marine Debris Monitoring Program and a study on the incidence of plastics ingestion in seabirds from the tropical Pacific Ocean. The debris monitoring program is a cooperative project being developed by MERP, the EPA, the NPS, and the CMC. Data from a number of sources, including the NMFS/NOS cooperative surveys, will be analyzed to develop a statistically-sound monitoring program. The second project was conducted by the Pt. Reyes Bird Observatory incidental to primary research efforts.

OFFICE OF FISHERIES INFORMATION SYSTEMS

After more than 50 modifications to the Request for Proposal and Benchmark for the IT-95 project (Information Technology for the '90s), two proposals for a new computer system for the AFSC were received in 1992. Office of Fisheries Information Systems (OFIS) staff participated in the evaluation of the proposals and traveled extensively to witness the benchmark processes. The IT-95 computer contract was awarded to Control Data Systems, Inc. of Arden Hills, Minnesota, in 1993 for a 64-bit multiprocessor CD9460 Challenge L System. A competitive contract was awarded to the UNISYS Corporation for an additional 3 years of Burroughs B7900 maintenance and software licensing. It was expected that the B7900 system would be replaced by the new Control Data CD9460 system during 1994.

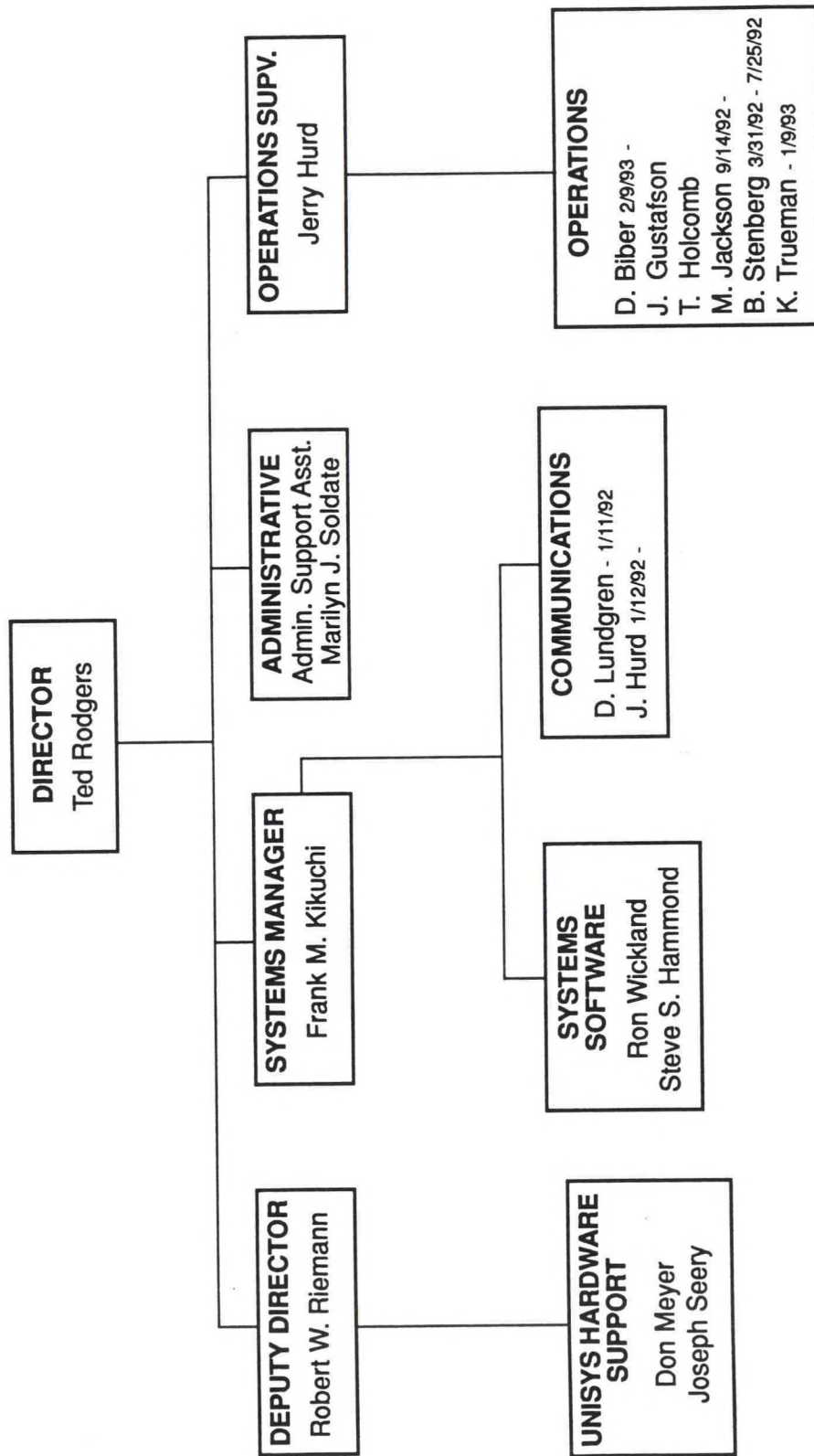
OFIS staff, in cooperation with automated data processing staff at the AFSC, installed a number of Local Area Networks to link up with a campus-wide integrated electronic network. OFIS, in cooperation with the Pacific Marine Environmental Laboratory, installed a fiber-optic link between the buildings at the Sand Point campus. Access to the Internet was made available to many AFSC staff. OFIS continued to provide technical and procurement assistance to AFSC Divisions and Laboratories, as well as to the NMFS Alaska Region, in the acquisition of personal computers, software, training, telecommunications equipment, and dedicated lines.

PUBLICATIONS UNIT

The Publications Unit continued to provide editorial and graphics services to AFSC scientists and administrators during 1992-93. In 1992, the Unit's editorial staff reviewed over 50 scientific manuscripts and published 14 AFSC Processed Reports and 9 NOAA Technical Memorandums. In 1993, staff reviewed 40 manuscripts and published 17 AFSC Processed Reports and 21 NOAA Technical Memorandums. The Unit also designed and produced two regional status of stocks Technical Memorandums, the 1990-91 AFSC Biennial Report, and four issues of the AFSC *Quarterly Report* during each calendar year.

Graphics personnel provided critical support in four areas—presentations graphics, computer graphics, scientific illustration, and photography. Posters, slides, and other presentation materials were designed and produced for use at national and international scientific symposia. Maps and other detailed illustrations were created consistently for use in scientific publications.

**OFFICE OF FISHERIES INFORMATION SYSTEMS
ORGANIZATION CHART
1992-93**



AUKE BAY LABORATORY

Research at the Auke Bay Laboratory (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 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 other two programs. The Marine Fisheries Assessment Program encompasses high-seas salmon studies, as well as research on fish species in the Gulf of Alaska, particularly sablefish (*Anoplopoma fimbria*) and rockfish (*Sebastes* spp.). 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.

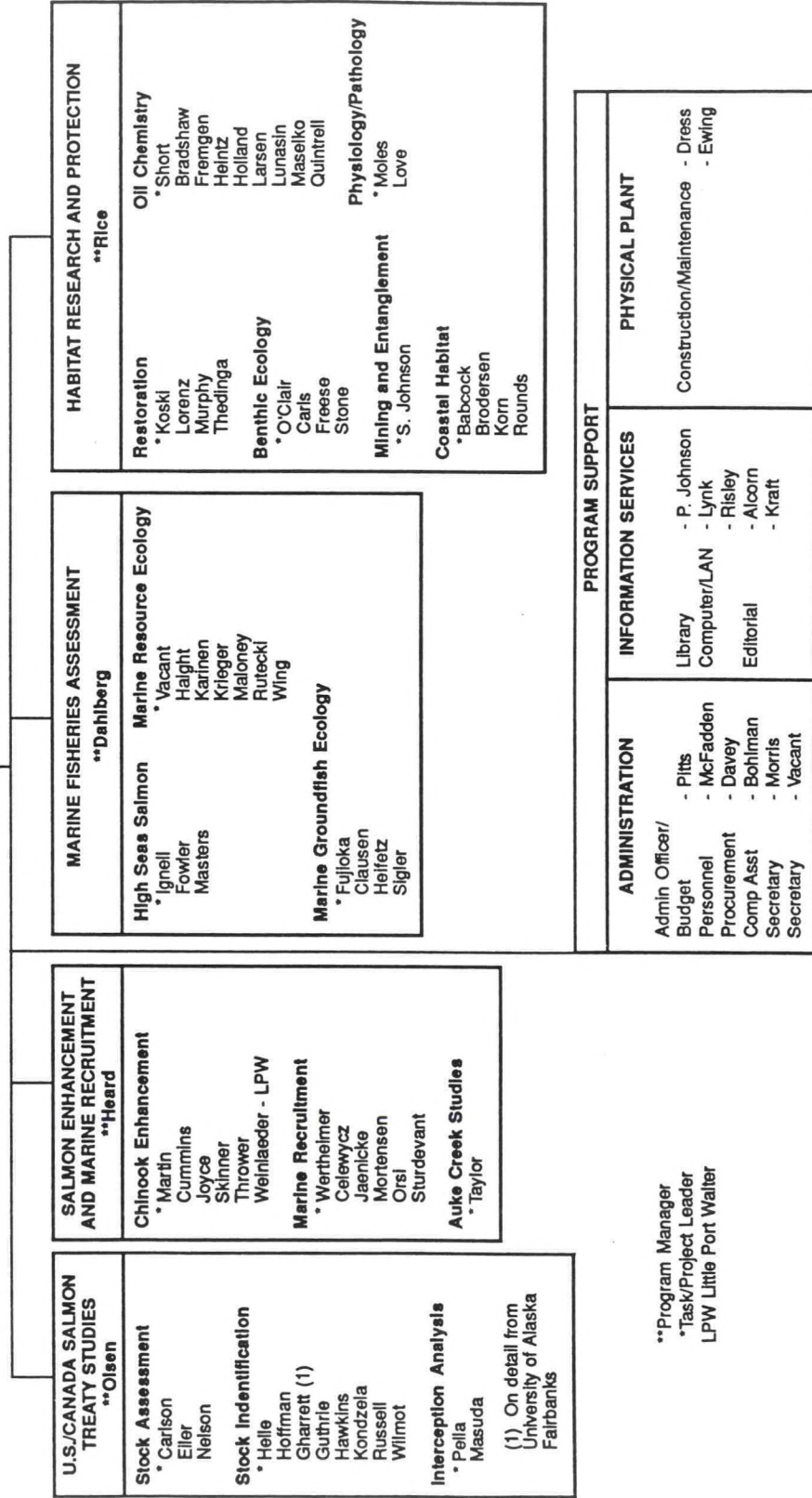
Salmon Enhancement and Marine Recruitment Studies

The Salmon Enhancement and Marine Recruitment Program has six principal objectives: 1) to develop enhancement technology to produce more chinook salmon (*Oncorhynchus tshawytscha*) for Alaska fisheries, including maintaining specific chinook salmon brood stocks for use in enhancement programs; 2) to work with the ABL Habitat Program to investigate the effects of the *Exxon Valdez* Oil Spill (EVOS) on salmon, including steps necessary for restoring damaged resources; 3) to work in cooperation with the University of Alaska Fairbanks to investigate the biology of interspecies Pacific salmon hybrids and associated variations in life-history traits; 4) to determine natural straying rates of wild salmon and the effects of different variables on homing fidelity; 5) to examine the growth and distribution of juvenile salmon in the marine environment and relate these data to environmental factors that affect marine recruitment and development of year-class strength; and 6) to conduct enhancement research necessary to restore the depressed Auke Lake sockeye salmon run and provide for urban-area sport fishing opportunities.

Research is carried out at three year-round field facilities; two on Baranof Island at Little Port Walter (LPW) and Osprey Bay, and one at Auke Creek near the ABL. In addition, marine recruitment studies are conducted throughout Southeast Alaska using the NOAA research vessel *John N. Cobb*.

AUKE BAY LABORATORY ORGANIZATION CHART 1992-1993

DIRECTOR Synder
DEPUTY DIRECTOR Greenough
SECRETARY Mynarski



Chinook Salmon Research and Enhancement

In a cooperative effort with the Alaska Department of Fish and Game (ADF&G) and others, studies since 1976 at LPW have focused on developing technology to enhance brood development, ocean survival, and egg production of chinook salmon, with the purpose of improving chinook resources and fisheries. Initially this research involved two chinook salmon stocks from the Unuk and Chickamin Rivers. In 1988, a third stock from the King Salmon River was added to the brood stock development and research program. These three chinook stocks are used in stock comparison studies of different enhancement treatments as well as brood stock development. Maintaining three separate anadromous stocks of the same species at one location is unparalleled in Pacific salmon research.

In 1993, 200,000 age-1 smolts from the three stocks were released at LPW, and 2,000 adults from earlier releases returned to LPW. Two million eggs were collected from these returning adults, including 500,000 eggs from the first returns of mature females (5 years old) from the King Salmon River stock. About 200,000 of the King Salmon River stock eggs were sent to Gastineau Hatchery in Juneau as part of an enhancement effort in that area. Another 500,000 Chickamin stock eggs were sent to Ketchikan hatcheries. Also, in 1992, about 600,000 Chickamin stock eggs were sent to the Neets Bay Hatchery in Ketchikan.

Other chinook salmon research at LPW included off-station releases of smolts in 1991, 1992, and 1993 to measure the effects of displacement on survival, growth, and homing behavior. One aspect of the study was to see if nearshore predators are adversely impacting smolt survival. The experiment was designed to measure these parameters in replicate groups of smolts released both at LPW and at a location 4 miles east of LPW in Chatham Strait. Data from both fishery and weir recoveries will be used to evaluate the potential for releases of this type.

Salmon Studies at Osprey Bay

In a cooperative program, two major studies initiated in 1989 are continuing at Osprey Bay. The first study is measuring the family variation observed in the life-history characteristics of captive-reared chinook salmon; for instance, the relationship between juvenile growth rates and age-at-maturation. The second study involves investigating life history and behavioral traits of interspecies Pacific salmon hybrids. The hybrid study measures survival, seawater tolerance, growth, and age-at-maturation of different groups reared to maturity in captivity. Both studies are undertaken in cooperation with the University of Alaska Fairbanks and the Western Regional Aquaculture Consortium (WRAC), a coastwide organization of universities and government fisheries concerns. To date, the project has identified several hybrid crosses

that display high growth rates, early seawater tolerance, and low rates of maturation. These projects are scheduled through 1994, with the present focus on rates of maturation and viability of gametes.

Does Oil Exposure Have Long-Term Effects on Pink Salmon?

Members of the Enhancement and Recruitment Program initiated a cooperative study with the ABL Habitat Program and the ADF&G in 1992 to investigate the effects of oiled incubation gravel on pink salmon (*O. gorbuscha*). Evidence from Prince William Sound, the site of the 1989 *Exxon Valdez* oil spill, indicates the possibility of both short- and long-term damage to oiled pink salmon streams. The study, conducted at LPW and Osprey Bay, involves incubating pink salmon embryos at a variety of oil exposure levels and measuring survival rates, histological effects, and oil uptake in the fry. Pink salmon surviving the initial exposures are being reared in captivity to assess possible differences among treatment groups with regard to survival, growth, and gamete viability. Fry from the same treatment groups were also coded-wire tagged in order to examine the parameters in a group released into the marine environment.

Sockeye Salmon Restoration Based on Age-0 Smolts

Most sockeye salmon (*O. nerka*) spend at least 1 year in fresh water before migrating to sea as smolts. This presumed freshwater requirement for most sockeye salmon stocks made this species an unlikely candidate for artificial enhancement. Recently, however, the occurrence of age-0 sockeye salmon smolts with limited freshwater residency has been documented in many Alaskan river systems. As a result, there is increasing interest in the possibility of utilizing this life history type for enhancement purposes. This concept is receiving the attention of Pacific rim nations and may have future impact on sockeye salmon programs in several countries.

At the Auke Creek experimental hatchery, studies have focused on the use of age-0 smolts to rehabilitate a badly depressed run of sockeye salmon in the Auke Lake system. Although there are no age-0 smolts in this system, experimental groups were released from the 1987 to 1991 broods. In some years, both seawater- and freshwater-reared smolts were released at several different times and sizes. In 1985, fewer than 400 adult sockeye returned to Auke Lake. By 1993, the run had increased to over 9,000 adults, and one-half of these were derived from experimental groups of age-0 smolts. Another 25% of the 1993 adults were from other forms of enhancement, namely the planting of young fry from the hatchery into the lake. The number of returning adults in 1994 is expected to exceed the number of last year's returns, and planning is now under way with the ADF&G to reopen a controlled recreational fishery for sockeye salmon at the mouth of Auke Creek.

Distribution and Growth of Juvenile Salmon in Marine Waters

Analysis of pink salmon scales collected by ABL scientists has shown that early marine growth is positively related to survival, but negatively related to size-at-maturity. This suggests that recruitment of large numbers of juvenile pink salmon from nearshore waters results in density-dependent effects on growth rates in coastal or off-shore waters, which cause reduced size of returning adults but do not cause increased mortality rates.

The marine recruitment staff is currently using the NOAA vessel *John N. Cobb* to sample juvenile salmon throughout the inside waters of Southeast Alaska. Distribution and habitat utilization will provide insight into questions on nearshore carrying capacity. Scale collections from these cruises will be used to determine the utility of using juvenile scales to forecast subsequent year-class abundances. Studies are also examining the relationships of spring zooplankton production to the growth and survival of juvenile pink and chum salmon (*O. keta*). This work includes developing index methodologies that can be readily adapted by enhancement operations for monitoring zooplankton for timing releases of hatchery salmon.

U.S./Canada Pacific 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 management and allocation issues of longstanding concern to the two nations. ABL staff serve on four Bilateral Technical Committees and the Research and Statistics Committee. Technical support by the ABL also assists U.S. negotiators in seeking agreements on salmon fisheries in northern British Columbia and Southeast Alaska. Research at the ABL includes stock identification, stock assessment, and interception analysis for fisheries that occur in boundary areas, transboundary rivers, and coastwide areas.

Another major program objective is to identify the origin of salmon intercepted in high-seas fisheries in international waters and to gain knowledge of ocean distributions and migrations of maturing salmon. Achieving this goal requires considerable international cooperation. The ABL is working closely with other U.S. scientists and is conducting collaborative studies with Russian scientists to add baseline information from Asian salmon stocks to 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 pink, sockeye, and chum salmon stocks from northern British Columbia. To date, approximately 30 chinook salmon collections, 70 chum salmon collections, 74 sockeye salmon collections, and 120 odd-year and 92 even-year pink salmon collections have been sampled. Pink, chum, and chinook salmon collections from Russia and Japan have also been sampled. These data are being collected to determine if sufficient genetic divergence exists to discriminate between Alaskan, British Columbian, and Asian salmon. Related work is the development of multi-attribute stock separation methods that combine genetic information (including mitochondrial DNA), 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, scientists from the Russian Academy of Sciences in Vladivostok and the KOTINRO laboratory in Petropavlovsk-Kamchatski have been hosted at ABL every year since 1991 to develop genetic baseline information on Asian pink, chum, sockeye, and chinook salmon stocks. Major goals were to identify stocks in high-seas bycatches, determine migration routes in the Bering Sea and North Pacific Ocean, and to assist Russia and Japan develop genetic stock identification methodologies for management of their fisheries. Such information is also useful for enforcement purposes. The ABL has responded to several requests from NMFS Enforcement Division agents to examine salmon high-seas catches.

Field collection of tissue samples from sockeye salmon spawning in the inlet stream of Redoubt Lake in Southeast Alaska. Genetic baselines have been developed from the extensive sampling of Southeast Alaska pink, chum, sockeye, and chinook salmon populations.



Stock Assessment

The Taku River, a large and turbid transboundary river, is an important producer of Pacific salmon. Since 1984, ABL has conducted telemetry studies on adult sockeye and chinook salmon spawners returning to the drainage. During 1992, telemetry studies were conducted to determine run characteristics for Taku River coho salmon (*O. kisutch*). Approximately 450 coho salmon were tagged with radio transmitters near the river mouth and tracked upriver. A remote tracking system was used to monitor the movements of the radio-tagged fish. Tracking stations, placed at key locations throughout the drainage, recorded the fish as they moved past the sites. This telemetry information was retrieved daily by the ABL via a NOAA satellite (GOES) to provide continual inseason analysis. Use of this tracking system provided the first detailed information on in-river distribution, stock timing, movement patterns, and nation of origin for coho salmon in the Taku River. This information could not have been obtained with conventional tracking methods (i.e., locating tagged individuals by foot or from vehicles, boats, or aircraft) due to the isolated nature of the drainage and inclement weather, typical for this area during the fall.

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 also may produce the largest chum salmon in North America. In 1992-93, the ABL continued to monitor returns to Fish Creek, thus adding to the 20-year data series, started in 1972, which provides an index of chum salmon stock status in Portland Canal. The data series shows a sharp decline in size-at-maturity of chum salmon, especially during the past 10 years.

Interception Analysis

Baseline samples for four discrete characters of individual fish (protein genetic characters PGM-1* and PGM-2*, presence of the brain parasite *Myxobolus neurobius*, and freshwater age at seaward migration) from 73 sockeye salmon stocks of Alaska and Canada were used to demonstrate the capacity to assess composition of mixed-stock catches. Southeast Alaska sockeye salmon catches from the Noyes Island fishery in 1986 and from the Sumner Strait test fishery in 1987 were sampled weekly for the same four characters. Estimated weekly contributions to the two fisheries by 13 groups of like stocks were generally consistent with expectations from tagging experiments, knowledge of magnitudes of sockeye salmon populations, and similar assessments based on scales

but were not precise enough to be of practical value. However, precision was much improved for combined estimates by high- and low-parasitized stock groups comprising those 13 originally considered. Noyes Island catches comprised predominantly unparasitized fish, most of which were probably of Canadian origin. The majority of Sumner Strait catches consisted of parasitized fish, whose origins could have been either Alaska or Canada.

Another study compared algorithms developed to compute the maximum likelihood estimates of stock composition from discrete characters sampled from catch and contributing stocks. The algorithms include one or more specializations of general optimization procedures including steepest ascent, expectation minimization, conjugate gradient, and iteratively reweighted least squares. Measures of performance included: 1) computer processor time required to guarantee that the search was within 10%, 50%, and 90% of the maximum of the likelihood function; 2) frequency of failure to achieve the specified guaranteed percent; and 3) stability of estimates as specified guaranteed percent was increased. Performance was compared both with real data as well as hypothetical data for which number of stocks, degree of stock differentiation, and sample sizes could be controlled. Speed of computation varied greatly among algorithms, and relative performance depended on the particular data sets. Generally, however, the conjugate gradient algorithm using a square root transform of the unknown stock proportions was quite fast, compared to the other algorithms. The iteratively reweighted least squares algorithm was very reliable in achieving the specified percent of the maximum likelihood value to be obtained. Also, the estimates from the iteratively reweighted least squares algorithm varied least as the specified guaranteed percent achieved was increased.

Marine Fisheries Assessment

The Marine Fisheries Assessment Program has two major elements: high-seas salmonid research and groundfish studies in the eastern Gulf of Alaska. Salmonid research involves monitoring the catch of salmonids in salmon and squid driftnet fisheries operating on the North Pacific Ocean and investigating the life-history and migratory patterns of salmonids in offshore waters. 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 Anadromous Fish Commission and at meetings relating to U.S. interests in international management of living marine resources.

Proximity to Alaska groundfish resources and their habitat allows ABL scientists to conduct field research to better understand these species and to improve our ability to assess their abundance. Research centers on estimating 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*); life history studies are also undertaken. Based on ABL studies, annual Status of Stock Reports are submitted to the North Pacific Fisheries Management Council, recommending allowable biological catch levels for sablefish, slope rockfish, and pelagic rockfish.

Salmonid Studies

An international milestone was achieved in 1993 when driftnet fishing nations, in response to U.S.-led international political pressure, agreed to a moratorium on large-scale pelagic driftnet fishing on the high seas. In 1991, total salmonid mortality was nearly 50,000 fish in the Japanese squid driftnet fishery and 16,000 fish in the Republic of Korea squid driftnet fishery—much less than in 1990, when over 200,000 salmonids were incidentally killed in the Japanese squid driftnet fishery alone. Studies during 1993 revealed that driftnet catch rates were affected by the total time the driftnets were fishing, the amount of daylight hours during the fishing period, and species behavior.

Most salmon (80%) were caught near the Emperor Seamounts in the western part of the squid driftnet fishery in the North Pacific Ocean. Results from analyses of physical oceanographic data collected by ABL scientists revealed that even though the seamounts occur 1,000 m below the surface, they alter surface currents and influence productivity through the formation of columns of rotating water, called Taylor columns. Analyses of driftnet bycatch data east of the seamounts showed that the spatial variation in salmon catches as a function of sea surface temperature (SST) was also associated with spatial patterns of forage species. These results provide indirect support to the bioenergetics hypothesis which assumes that salmon are distributed in a manner that maximizes growth and that growth is dependent on both SST and available forage.

Catch data collected by international observer teams in the Japanese squid driftnet fishery were also used to assess interrelationships among fauna along the North Pacific Subarctic Frontal Zone (SFZ). One key result was the identification of a gradient in species characteristics among all but 2 of the 25 species or species groups analyzed in the study, implying the existence of an underlying ecological gradient affecting species compositions in the SFZ. Pacific salmon and pelagic armorhead (*Pentaceros richardsoni*) were the two exceptions. The two most abundant species caught in the driftnet operations, neon flying squid (*Ommastrephes bartrami*) and Pacific pomfret (*Brama japonica*), were also the two species most pervasive among communities. Using classification methods, driftnet operations were categorized into at least two communities, one representing cool SSTs in the western part of the fishery and the other representing warmer SSTs in the east. Our results suggest that in the SFZ, where our sampling occurred, relationships among the pelagic fauna changed continually in association with an underlying environmental gradient across the study area.

Sablefish and Rockfish Research

Annual longline surveys, which provide basic information used in assessing the abundance of sablefish in the Gulf of Alaska, were continued in 1992 and 1993. As in prior years, both U.S. domestic and U.S./Japan cooperative longline surveys were conducted. Staff from the ABL and the AFSC's Resource Assessment and Conservation Engineering (RACE) Division coordinated the planning and execution of these surveys. Additional studies to compare differences in catch rates between the two surveys were conducted by RACE staff.

Other sablefish research during 1992 and 1993 included: study of otoliths recovered from known-age sablefish to validate age reading methods; studies using timing devices attached to longline gangions to evaluate effects of fish behavior and gear saturation on longline survey gear; analytical studies of quota strategies to minimize risk of overfishing due to uncertainty of biological parameters and recruitment; and continued efforts to increase tag recoveries and analyses to evaluate optimal allocation of area-specific quotas.

In 1993, ABL scientists conducted the fourth triennial trawl survey of groundfish resources in the eastern Gulf of Alaska. The survey was done in conjunction with a similar survey of the central and western Gulf of Alaska by RACE Division scientists. Although biomass estimates from these trawl surveys are used in AFSC rockfish stock assessments, the input has limited value. Estimates of abundance vary widely between surveys, and rough bottom conditions preclude standard survey trawling in many areas which may contain significant rockfish biomass. Recognizing the limitations of current survey methods in assessing rockfish, ABL scientists have participated along with other AFSC scientists in various activities aimed at improving the Center's capability to assess the biomass of rockfish. In 1992, observations of rockfish factory trawler fishing operations led to the design and implementation of a pilot survey, conducted in 1993, utilizing the specialized gear and skill used by fishing masters on these vessels. A factory trawler was chartered to conduct trawl hauls in a manner valid for a scientific survey. In 1992, another approach to reduce uncertainty in rockfish assessments was to use a two-person submersible to observe rockfish habitat preference and to groundtruth plats of various types of substrate. In 1993, high resolution hydroacoustic records of these substrate plats were taken to develop efficient methods of classifying and cataloging rockfish habitat in the Gulf of Alaska.

Other rockfish research during 1992-93 included studies of rockfish stock structure such as 1) comparing parasite and morphology of shortraker and roughey rockfish samples collected from the eastern and western extremes of the Gulf of Alaska and 2) electrophoretic genetic analyses of samples of shortraker and roughey rockfish from the eastern Gulf of Alaska. Considerable analysis to evaluate rebuilding the biomass of Pacific ocean perch was conducted in conjunction with other Center scientists.

Ten ABL scientists of the Marine Fisheries Assessment staff presented the majority of the papers given at the International Symposium on the Biology and Management of Sablefish, held 13-15 April 1993 at the AFSC. Scientists from Canada and the United States participated in the meeting, which was organized into five sessions: early life history, juvenile and adult biology, stock delineation and movement, stock assessment, and management.

Habitat Research and Protection

The Habitat Program's purpose is to provide resource managers with the best scientific information to support their management decisions for species harvests and habitat protection. Research focuses on natural and man-caused environmental perturbations that affect marine and anadromous species. Since March 1989, the *Exxon Valdez* oil spill (EVOS) has dominated habitat issues in Alaska and has changed our research priorities. The ABL has participated in several damage assessment studies in support of the EVOS Trustee Council's litigation efforts, and since the settlement, has initiated work in support of restoration of damaged resources and habitats. Over one-half of the funding provided by the EVOS Trustees and over one-half of the research effort in ABL's Habitat Program is directed toward EVOS research and habitat restoration.

In addition to oil spill-related studies, several smaller research projects were conducted during 1992-93. Because operational funds have been severely limited, however, research priorities were often set by the availability of "soft funds" contributed from outside sources. In 1993, for example, funds from the City of St. Paul, Pribilof Islands, supported subtidal surveys of seafood processor outfalls which were examined at the request of the Alaska Region's Protected Resources Management Division (PRMD). Other ongoing studies examine restoration of anadromous fish habitats, changes in abundance of derelict fishing gear on Alaska beaches, impacts of mining operations on nearshore habitats, and effects of fishing pressure on Dungeness crab population structure.

Exxon Valdez Oil Spill Studies

The *Exxon Valdez* oil spill and its long-term impact on Prince William Sound (PWS) still dominate habitat research in Alaska. Five years after the spill, oil is still evident. The crash of PWS salmon and herring stocks in 1993 suggests subtle, long-term damages that are difficult to understand. Impacted members of the fishing industry have demanded further broad-based studies. ABL research focuses primarily on hydrocarbon issues: monitoring oil in the environment and ecotoxicity. In 1993, the EVOS Trustee Council funded four ABL studies: 1) technical

support in hydrocarbon analysis and database management, 2) monitoring of restoration and recovery of oiled mussel beds, 3) monitoring of hydrocarbon load in subtidal sediments, and 4) determination of genetic aberrations in pink salmon incubated in oiled substrates.

ABL scientists provide technical support in hydrocarbon analysis, interpretation, and management of the extensive hydrocarbon database. In 1992 and 1993, ABL chemists analyzed 1,700 marine sediments and tissues for hydrocarbons by gas chromatography and mass spectrometry for the final Natural Resource Damage Assessment (NRDA) projects and the first restoration projects. The chemical analyses are evaluated and entered into the Trustee Council's database, in which thousands of analyses are stored. The data are made available and interpreted to all resource agencies, principal investigators, and interested parties upon request. Results of the latest nationwide Biennial Quality Assurance Study, organized by the National Institute of Standards and Technology, again ranked the ABL with the Nation's best laboratories for hydrocarbon analysis.

The persistence of substantial amounts of petroleum hydrocarbons under mussel beds in PWS and the Gulf of Alaska is a continuing source for petroleum hydrocarbons to enter the food chain. The highest oil concentrations in sediments and in tissues (mussels) have been found in some mussel beds on soft sediments. In 1992, ABL documented *Exxon Valdez* oil in underlying sediments in more than 50 mussel beds in PWS. In half of the beds, petroleum hydrocarbon concentrations in sediment were higher than 10,000 $\mu\text{g/g}$, and polynuclear aromatic hydrocarbons in mussels reached 10 $\mu\text{g/g}$. Reductions in oil concentrations between 1992 and 1993 by natural processes were not encouraging. To evaluate potential restoration techniques, ABL researchers experimentally cleared strips and patches in test beds to try to hasten flushing of oil from the underlying sediments. Although hydrocarbons were reduced within the cleared areas, adjacent areas did not show enough of a reduction to warrant further consideration of these methods for restoration purposes. Results from this study led the Trustees to approve for 1994 the physical removal of oiled sediments underlying several of the most contaminated beds.

The ABL is monitoring the recovery of oil-contaminated subtidal marine resources in PWS. Monitoring hydrocarbons in subtidal sediments began a few weeks after the 1989 *Exxon Valdez* oil spill. At that time, the NRDA found that at some heavily oiled sites sediments at a depth of 0-20 m had been contaminated by oil. In 1993, 190 sediment samples were collected for hydrocarbon and microbial analysis at depths from 0 to 100 m from five oil-contaminated bays and five reference bays. Such data will be used to track the progress of natural recovery of the subtidal sediments in PWS. Concentrations of subtidal oil are relatively low compared to oiled mussel beds.

Investigators from the ABL are assessing the genetic effects of long-term oil exposure on developing eggs and alevins of pink salmon. The project

uses controlled laboratory oil exposures to simulate the long-term oil exposures that intertidally spawned eggs and alevins of pink salmon were exposed to in 1989 and 1990. ABL's study is designed to determine if elevated pink salmon egg mortalities in oiled streams observed by the ADF&G in 1989-93 could have been caused by genetic damage due to oil exposure during the egg and alevin life stages. Since 1992, pink salmon eggs and alevins have been incubated in oil-contaminated experimental substrates; impacts on survival and growth have been measured from exposures of less than 1 ppm. Genetic damage will be determined by viability and fertility of offspring when the juveniles are reared to maturity and spawned in 1994 and 1995.

Restoration of Anadromous Fish Habitats

Scientists from the ABL are helping to restore Juneau's Duck Creek, one of 20 streams listed by the Alaska Department of Environmental Conservation as impaired by urban development. ABL scientists, in partnership with Trout Unlimited, the ADF&G, the U.S. Forest Service, other agencies, and private citizens, are developing a comprehensive restoration plan for the Duck Creek basin. Restoring Duck Creek will provide a valuable example of the feasibility to restore other impaired streams, increase anadromous fish populations, and familiarize the public with the many values of their urban streams.

Past logging practices have left many anadromous fish streams in need of restoration. Millions of dollars are spent to restore streams, but efforts lack evaluation. To address this need, ABL initiated organization of a multiagency project partially funded through the Clean Water Act to study methods for effective restoration. The ABL is also producing a Management Synthesis for NOAA's Coastal Ocean Program, which will synthesize information on protection and restoration of anadromous fish habitat.

Satellite imagery is being developed by NOAA's CoastWatch Change Analysis Program (C-CAP) as a method of monitoring coastal water quality. In 1993, ABL assisted C-CAP by ground-truthing satellite imagery of the Yakutat/Situk River in Alaska. Classification maps based on satellite imagery will help monitor natural and man-induced changes in coastal habitat.

Surveys of Stranded Trawl Web on Alaska Beaches

Scientists at the ABL have surveyed Alaska beaches since 1972 to monitor trends in the occurrence of derelict fishing gear and other plastic debris washed ashore. Since 1988, studies have had an increased significance because of the passage of an international law (MARPOL Annex V) that prohibits dumping at sea. The ABL's beach surveys have documented that MARPOL is working. The occurrence of trawl web has declined for 5 consecutive years.

Impacts of Mining

In response to increasing fisheries concerns about mining impacts, the ABL has broadened its capabilities for the analysis of heavy metals and has undertaken several related studies of mining impacts. In cooperation with the National Park Service, the ABL examined impacts of the Red Dog Mine's marine ore terminal on benthos in six coastal lagoons in the Cape Krusenstern National Monument. Sediment from lagoons near the ore terminal contained elevated levels of lead, cadmium, and zinc. Benthos communities differed among the lagoons, depending primarily on salinity.

In another cooperative study, ABL and the Bureau of Mines are examining 75-year-old mine tailings in Gastineau Channel near Juneau to assess long-term effects of tailings deposits. Significantly higher levels of lead, zinc, cadmium, selenium, and arsenic were found in the old tailings than were found in control sediments. Laboratory bioassays with clams and juvenile Tanner crabs are ongoing to determine the metal uptake from the old tailings.

Impacts of Fishing on Dungeness Crab Stock Structure

ABL is cooperating with the National Park Service, the University of Alaska and the ADF&G to assess the effects of the commercial crab fishery on Dungeness crab (*Cancer magister*) populations in Glacier Bay. Crabs were sampled in 1992-93 before the anticipated closure of the fishery in the park. Average crab density ranged from 78 to 2,012 crabs/hectare, depending on sex, reproductive state, and date. Future sampling will identify sources of seasonal and annual variation.

Seafood Processor Outfalls

In cooperation with the City of St. Paul and the Alaska Regional Office, the ABL is monitoring impacts of seafood processor outfalls on nearshore habitat in the Pribilof Islands. Three processor outfalls currently discharge a maximum daily total of 4.5 million l of waste slurry into the marine environment. Persistent deposits of organic waste can degrade benthic habitat and cause hypoxia and high levels of toxic sulfides. Organic debris also can be deposited intertidally by winds and currents. Large rookeries of northern fur seals near the outfalls could be affected by the waste. In 1993, before the processors began operating, ABL scientists collected baseline data on subtidal and intertidal habitat, biotic communities, water chemistry, and sediment concentrations of carbon and hydrocarbons near the planned outfalls. The area was mapped and documented with video and photography. Follow-up surveys are scheduled in 1994 to determine if intertidal and subtidal habitats have been impacted by the outfalls.

NATIONAL MARINE MAMMAL LABORATORY

The National Marine Mammal Laboratory (NMML) 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.

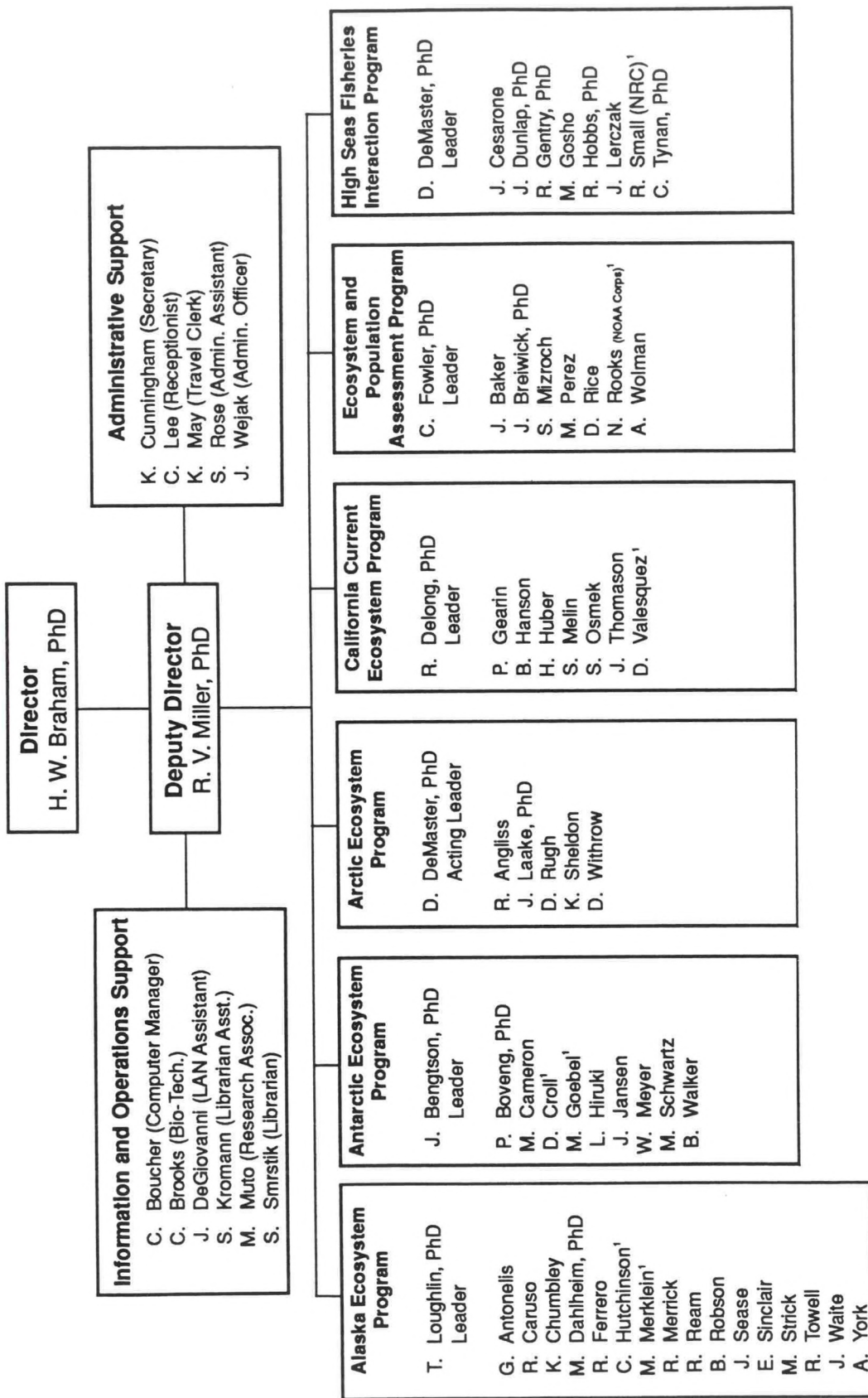
Antarctic Ecosystem Program

The Antarctic Ecosystem Program conducts pinniped and seabird research identified under the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR). These projects are carried out as part of the CCAMLR Ecosystem Monitoring Program (CEMP), a multinational program designed to detect significant changes in key components of the Southern Ocean ecosystem and distinguish between changes due to commercial fisheries and those due to natural causes. The underlying objectives of this research are to determine what factors are primarily responsible for influencing the population dynamics of Antarctic pinnipeds and seabirds. Current studies focus on predator feeding ecology, reproductive success, growth and condition, demography, abundance, and prey availability and environmental conditions. There are two principal projects within this program: 1) fur seal and seabird ecology and 2) pack-ice seal ecology.

Antarctic Fur Seals and Seabirds

Pinniped and seabird research projects have been conducted at the NOAA field camp on Seal Island, South Shetland Islands, Antarctica, since the 1986-87 austral summer. Antarctic fur seals (*Arctocephalus gazella*) and seabirds prey on Antarctic krill (*Euphausia superba*) and selected finfish species within areas of important commercial fisheries. Because fur seals and birds pup or nest ashore at traditional sites, they are well-suited to annual, long-term studies of their ecology and behavior. Specific research topics addressed by the Seal Island studies include: 1) assessing pup growth rates and foraging behavior of Antarctic fur seals, 2) evaluating pup production, diet, abundance, survival, and recruitment of fur seals, 3) evaluating the breeding success, fledgling size, reproductive chronology, foraging behavior, diet, abundance, survival, and recruitment of chinstrap (*Pygoscelis antarctica*) and macaroni (*Eudyptes chrysolophus*) penguins, and 4) assessing the growth and condition of chinstrap penguin chicks and seasonal patterns in the diving behavior of adult chinstrap penguins in relation to intra- and interannual changes in food supply and environmental conditions.

NATIONAL MARINE MAMMAL LABORATORY ORGANIZATION CHART 1992-93



¹ Left NMML During FY 1993

Analyses of stomach and fecal contents of fur seals and penguins have shown that krill predominates these predators' diets. Prey fed to penguin chicks by their parents contained 99% krill by weight. The principal diet of fur seals varied from 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. In each of the past two field seasons, time-depth recorders (TDRs) and/or radio transmitters were attached to 40 fur seals and 80 chinstrap penguins to assess foraging behavior. Fur seals and penguins foraged at depths averaging 20-30 m and 35-50 m, respectively.

Pack-Ice Seals

Research in the pack-ice zone is conducted to complement land-based studies at Seal Island. The most ecologically important Antarctic pinniped species are those inhabiting the sea-ice zone, with crabeater seals (*Lobodon carcinophagus*) being the most abundant. Crabeater seals are the focus of studies in which foraging ecology, demography, distribution, and abundance are investigated. As logistic support allows, field work includes on-site surveys and investigations using remote-sensing technology. Satellite telemetry has been successfully utilized to assess the seasonal movements, habitat use, foraging behavior, and activity patterns of crabeater seals in the Weddell Sea and along the western coast of the Antarctic Peninsula. Crabeater seal data and specimen material from a variety of sources over the past 25 years have been compiled into a database at the NMML. Analyses of the seals' reproductive status and age distribution have revealed patterns of increasing age at sexual maturity and fluctuating cohort strength. NMML scientists are continuing these analyses in an attempt to explain the causes of these fluctuations.

Arctic Ecosystem Program

Gray Whales

The 1992-93 shore-based survey of southbound migrating gray whales (*Eschrichtius robustus*) took place between 10 December 1992 and 7 February 1993. Survey methods were the same as in previous seasons. Paired, independent counts were made whenever possible. A total of 2,112 whales was observed during 343 hours of survey effort. The preliminary population estimate is 17,674 (95% CI: 15,800 - 19,800), which is significantly lower than the 1987-88 estimate of 20,869 (95% CI: 19,200 - 22,700). Possible reasons for the difference include: 1) differences in the percentage of animals that migrated past the shore station, 2) differences in average sighting conditions, especially near the peak of the migration, and 3) unobservable heterogeneity in the probability of sighting animals.

The 1993-94 shore-based survey of southward migrating gray whales was initiated on 10 December 1993. Survey methods were similar to those used in previous surveys. As anticipated, few sightings were reported in the first week of observations (i.e., the average number of sightings per day over the first 12 days was 1.4 pods). By 25 December, the sighting rate had increased to over 15 pods per day. Survey effort will continue until 18 February 1994 to document the end of the migration. In addition to shore counts, aerial surveys will be conducted 5-18 January 1994. A thermal sensor will be used to compare swimming speeds of whales migrating at night and during the day.

The 1988 amendments to the U.S. Endangered Species Act (ESA) specify that monitoring plans be developed and implemented for any vertebrate population that is removed from the list of endangered and threatened wildlife. An initial period of 5 years post-delisting was specified in the ESA for monitoring and assessment. The Assistant Administrator for Fisheries appointed a task group under the direction of the NMML to develop a research and monitoring plan for the eastern North Pacific Ocean population of gray whales, which the NMFS has proposed for delisting. The 5-year plan was submitted to the Assistant Administrator for Fisheries in October 1993 and is expected to be published as a NOAA Technical Memorandum in 1995.

Bowhead Whales

No field work was conducted on bowhead whales (*Balaena mysticetus*) because of a lack of funds. However, several data analyses were conducted at the NMML and were scheduled to be presented at the May 1994 meeting of the International Whaling Commission (IWC). Research topics included: 1) summary and update of length frequency data from aerial surveys (1985, 1986, 1989-92), 2) evaluation of timing of the spring and fall migration on the analysis of length frequency data, and 3) summary of all data on bowhead whaling by subsistence hunters between 1973 and 1993. In addition, NMML staff have cooperated with staff from the NMFS Office of Protected Resources and Alaska Regional Office in reviewing the Atlantic Richfield Company's monitoring plan for determining the extent to which bowhead whales may have been impacted by drilling and seismic operations in Camden Bay, Alaska, in fall 1993.

Beluga Whales

Field research on beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, was initiated in summer 1993 with funding from the NMFS Office of Protected Resources. The studies included aerial surveys in June, July, and September to determine the optimal survey period and survey technique; the studies also included the genetic analysis of tissue to determine the extent to which beluga whales in Cook Inlet are isolated from other population centers of beluga whales. Information

collected during the aerial surveys is consistent with information collected during previous surveys in Cook Inlet by the NMFS Alaska Regional Office and the ADF&G, which indicate maximum counts between 270 and 332 animals. Planned research in 1994 includes efforts to develop photogrammetric techniques to determine the percentage of animals not included in the count because of diving behavior. Plans are under way to attach radio-tags to animals in Cook Inlet to derive independent correction factors for aerial surveys. Results of the genetic analysis, conducted by staff from the Southwest Fisheries Science Center (SWFSC), are currently unavailable. All NMML research on beluga whales is in accordance with recommendations from the Alaska Inuvialuit Beluga Whale Committee.

Spotted Seals

With funding from the Office of Protected Resources, research on the spotted seal (*Phoca largha*) in Alaska included: 1) aerial surveys in late summer of coastal rookeries and haul-out areas and 2) attachment of satellite tags to seven spotted seals in the vicinity of Pt. Lay, Alaska. Aerial surveys were conducted from 5 to 17 September 1993 and included haul-out areas between Kotzebue and Scammon Bay, and St. Lawrence Island, Nunivak Island, and Kuskokwim Shoals. Attempts to count undisturbed spotted seals by flying at altitudes between 600 and 1,500 m were partially successful. In general, survey conditions were good and were synchronized with low tides at known haul-out sites. A total of only 470 seals were counted (all in the water) north of Kuskokwim Shoals, while a maximum of 2,471 seals were counted at Kuskokwim Shoals. However, information sufficient for estimating abundance of the spotted seal population in the Bering and Chukchi Seas currently is not available.

Photogrammetric surveys were done in cooperation with staff from the SWFSC. Interpreting photographic images taken from altitudes above 300 m is possible because of the excellent optics of the cameras used during the surveys. Satellite telemetry research, conducted to ascertain movement patterns and the proportion of time animals are hauled-out during survey periods, was a cooperative study involving NMFS, the ADF&G, the North Slope Borough, and Texas A & M University. In addition, data on food habits, physiology, and stock discreteness were collected. The stock identification studies were done in cooperation with the SWFSC.

Alaska Ecosystem Program

Northern Fur Seals

Northern fur seals (*Callorhinus ursinus*) were studied at their breeding rookeries on the Pribilof Islands (St. Paul Island and St. George Island)

and Bogoslof Island in the Bering Sea, and on San Miguel Island in the California Channel Islands.

In July of 1992 and 1993, counts of adult male fur seals were conducted on the Pribilof Islands. The 1992 count of territorial adult males increased by 15% on St. Paul Island and 40% on St. George Island compared to the 1991 count. The 1992 increase in the male count on St. George Island was the first since 1986. Counts in 1993 also showed an increase of 17% on St. Paul Island and 9% on St. George Island relative to 1992. Counts of nonterritorial adult males also increased by 15% on St. Paul Island and 44% on St. George Island in 1992, but decreased on St. Paul and St. George Islands in 1993 by 15% and 22%, respectively. The overall decrease (5%) in the abundance of adult males in 1993 may signal the end of the accumulation of males in older age groups following cessation of the commercial harvest on St. Paul Island after 1984.

Mark-recapture estimates of pup abundance were made on the Pribilof Islands in August 1992. The estimated number of pups born on St. Paul Island indicated no significant difference in the trend of pup production between 1981 and 1992. Pup production estimates on St. George Island in 1992 indicated no significant difference in the 5.7% declining trend which began in 1973.

Fishing nets and other debris were removed from 50 fur seals on St. Paul and St. George Islands in 1992 and from 42 fur seals in 1993. Entanglement studies conducted in 1992 indicated that the rate of juvenile males entangled (0.29%) in debris (primarily trawl netting) has decreased significantly in recent years, but overall entanglement rates have not changed substantially since studies began in 1987.

During July-October 1992, radio and satellite transmitters were applied to 9 adult female fur seals and 12 adult males captured on St. Paul Island to determine foraging location, dive behavior, and migratory behavior. During August and September on St. George Island, a prey capture study was conducted based on deployment of TDRs on five adult females.

Scat collections continued in 1992 and 1993 on both St. Paul and St. George Islands as part of a long-term feeding study. Diet differed significantly between the populations on the two islands in the 1980s and early 1990s, making foraging studies an important tool in determining the differential success of the two island populations. Blood, tooth, and tissue samples also were collected from juvenile males killed in the subsistence harvest, and dead pups were necropsied as part of the monitoring effort.

During July and August 1993, researchers from the Institute of Far Seas Fisheries in Japan initiated a cooperative study to assess the reproductive success of adult male fur seals by testing the paternity of pups. Eight territorial males and 12 post-parturient females were tagged, and tissue samples were collected for genetic analysis to determine the

paternity of pups born in 1994. Cooperative research with Russian scientists in 1993 included a neonatal growth and survival paper based on data collected between 1982 and 1989 on northern fur seals from Bering Island, Russia.

Research on Bogoslof Island in 1992 and 1993 consisted of direct counts of live pups, which indicate that the population continues to grow rapidly. Counts during August 1993 recorded 5,544 fur seals, of which 898 were pups.

Harbor Seals

In Alaska, harbor seals (*Phoca vitulina*) range throughout southeastern Alaska waters, the Gulf of Alaska and Aleutian Islands region, and Bristol Bay (to about lat. 59°N). Once, harbor seals were considered abundant in all parts of their Alaskan range until surveys by ADF&G researchers in the 1980s indicated declining trends in some areas. NMML has conducted surveys in Alaska intermittently since 1976 and yearly since 1991 to obtain a minimum population estimate for the state. In 1991, Bristol Bay and the north side of the Alaska Peninsula were surveyed.

The objective of 1992 research was to determine a minimum population estimate of harbor seals in the Gulf of Alaska along the south side of the Alaska Peninsula, Cook Inlet, Kenai Peninsula, and the Kodiak Archipelago. Trend sites in Prince William Sound were also surveyed.

By conducting repetitive aerial surveys during August and September 1992, a minimum population estimate of 7,823 was obtained for harbor seals in the Gulf of Alaska and Prince William Sound. This estimate is significantly less than the number counted during earlier surveys and is part of a continuing decline first observed by ADF&G scientists in the 1980s. On Tugidak Island, for example, mean counts from repetitive surveys during the molt were 6,919 in 1976 and 1,014 in 1988. The decline there continues with mean land counts at 960 in 1990 and 571 in 1992. The number of harbor seals in the Kodiak Archipelago also declined 87% from counts in the late 1970s. The cause or causes of the decline in harbor seal abundance in Alaska are unknown. Harbor seals are incidentally caught in commercial net fisheries in Alaska and are killed by native Alaskans for subsistence purposes. The nature and magnitude of the incidental takes are unknown.

Similar studies were conducted in 1993 in southeastern Alaska. Mean counts of seals at the Sitka trend sites were lower, but not significantly different from those in the 1980s. In the Ketchikan area, counts of seals at trend site locations were significantly less than in earlier surveys. The maximum counts of all areas surveyed totalled 22,447 (CV = 2.6%)

Steller Sea Lions

Aerial surveys of adult and juvenile Steller sea lions (*Eumetopias jubatus*) were conducted by NMML and the ADF&G during June 1992 at all rookeries and most haul-out sites in Southeast Alaska, the Gulf of Alaska, and the Aleutian Islands. A minimum of two surveys were made of all trend sites in the area, and at least one survey of all other sites. A total of 34,844 adult and juvenile sea lions was counted in 1992 at the 95 trend sites in the area from Southeast Alaska through the western Aleutian Islands. The 1992 count is a decrease of 4.4% from the 36,459 animals counted in the same area in 1991 and a decrease of 70.2% from 1979 (116,804). The annual rate of decline from 1979 to 1992, based on linear regression, was 9.6% ($P = 0.0026$). Of the 95 trend sites, 32 are rookeries. The estimated annual rates of decline for these rookeries were 10.2% ($P = 0.001$) for 1979 to 1992 and 5.4% ($P = 0.06$) for 1989 to 1992.

Ship-supported on-land counts of pups were made during June-July 1992-93 at rookeries in the Southeast Alaska to eastern Aleutian Island area. Pup abundance during 1990-93 declined at a rate of 10.7% per year, from 9,581(± 471) in 1990-91 to 7,632 (± 281) in 1992-93.

A population viability analysis was prepared to evaluate the potential for extinction of the Alaska Steller sea lion population. Three models were developed based on the 1985-92 population trend. Two (an all-Alaska model and a Kenai Peninsula-Kiska Island model) were based on the trajectory of the sum of the rookery populations within their respective areas. A third was based on a simulation of the population trajectories of individual rookeries in the Kenai-Kiska area. All three models predicted that the Alaska population will be reduced to levels approaching extinction within 100 years if the 1985-92 trend persists. Both the all-Alaska and Kenai-Kiska models predict that the probability of extinction approaches 1.0 at 100 years. Mean times to extinction were 75 and 60 years, respectively. The individual rookery simulation predicted a longer time to extinction due to the persistence of small populations on several rookeries; however, the probability of extinction was still greater than 0.10 at 100 years. Results indicated that if the 1985-92 trend persists, the next 20 years may be crucial to the survival of the Alaska population. Though the population will not go extinct within 20 years, populations on individual rookeries may be reduced to low levels (mean size may be less than 100 adult females). After 20 years, rookeries may rapidly begin to disappear as the population contracts to the core of the range in the western Gulf of Alaska and eastern Aleutian Islands. At about the time most rookeries have been vacated, extinction probabilities will increase rapidly. Thus, if the 1985-92 trend persists, the models predict that in about 100 years the only Steller sea lions remaining in the United States would be in the area between southeastern Alaska and northern California. However, should the more moderate recent (1989-92) trend continue, mean times to extinction would be significantly longer (i.e., 207 years for Alaska and

Ongoing studies on the foraging ecology of Alaska Steller sea lions are conducted via satellite-linked telemetry. Here, a NMML scientist attaches a satellite transmitter to an adult female.

148 years for the Kenai Peninsula-Kiska Island area).

Stock differentiation studies using mitochondrial DNA(mt DNA) and nuclear DNA analysis continued during 1992-93. Tissue samples were collected from flippers of adults and pups at sites in Southeast Alaska, Prince William Sound, the Gulf of Alaska, the Aleutian Islands, and Russian waters.

Initial results indicate that Steller sea lions in the area from Oregon through Southeast Alaska can be genetically differentiated from animals to the west.

Researchers from NMML and the ADF&G conducted an aerial survey (using similar methods to summer surveys) during March 1993 from Southeast Alaska westward to Attu Island in the western Aleutian Islands. The survey was designed to determine the winter distribution of sea lions and not to estimate the population size. The survey found 26,669 animals at the sites, 58.8% of the number (45,329) recorded in the summer 1992 survey. The number of animals on haul-out sites was greater in March than in June, but rookery numbers were much lower in March. A number of rookery sites were either empty or nearly empty in March. A larger proportion of animals was observed in the western Gulf of Alaska and central Aleutian Islands in March than in June.

Field teams worked at Marmot Island (near Kodiak Island) during June-July 1992-93 to count survivors of the 1987-88 sea lion cohorts. During 1987-88, a total of 800 Steller sea lion pups (424 females and 376 males) were marked at Marmot Island in a long-term study of Steller sea lion dispersal, survival, and reproduction. Based on previous



research, it was estimated that nearly 100 females should be resighted at Marmot Island in 1992-93 out of the original 424 female pups. A maximum of 15 marked females were resighted during 1992-93 at the island. This supports the hypothesis that decreases in juvenile survival rates during the 1980s played a major role in the population declines observed at Marmot Island in the past decade.

Changes in the physical condition of Steller sea lion pups do not appear to provide an explanation for the decline in juvenile survival rates. During 1987-93, 611 Steller sea lion pups were weighed at seven rookeries in the area of Alaska presently experiencing a population decline. The average mass for 293 female pups was 26.9 kg and for 318 male pups was 32.5 kg. Pups were also weighed at rookeries in areas not experiencing population declines. At Forrester Island, Alaska, in 1990 the average mass of 120 female pups was 25.0 kg and of 119 male pups was 28.8 kg. Another 198 female pups (\bar{X} = 20.7 kg) and 202 males pups (\bar{X} = 24.8 kg) were weighed at Rogue Reef, Oregon, during 1985-88. Data were also available from 37 female pups (\bar{X} = 24.7 kg) and 64 male pups (\bar{X} = 28.9 kg) which had been weighed in the decline area in 1975, prior to the onset of the decline. An analysis of covariance was performed to determine if pup mass in the decline area was significantly different from pup mass in areas not experiencing declines. After removing the effects of the variables of date-of-weight and sex-of-pup, it was found that pup mass in the decline area was equal to or greater than pup mass in other areas. As such, the cause of the decline does not appear related to reduced pup condition during the first month postpartum.

Scientists from NMML continue to study the foraging ecology of Alaska Steller sea lions. Twelve Steller sea lions (7 adult females and 5 pups) were tracked during 1992-93 via satellite-linked telemetry. In summer, adult females ($n=3$) foraged relatively close to the rookery, usually within 20 nautical miles (nmi). In winter, adult females ($n=4$) were wide ranging, and showed preferences for different foraging areas. Both female and male pups moved long distances (from 60 to 250 nmi) as early as their fifth month. They appeared to forage over a similar range as adult females. Pups through their 11th month (May) appear to be shallow divers (2 m). Consequently, even though they may range widely, they may exploit prey in a very limited portion of the water column. Eastern Aleutian Islands animals (with the exception of one pup who went to the Pribilof Islands) generally foraged on the shelf area within the Krenitzen Islands and to the east on the north and south sides of Unimak Island. Kodiak Island area animals tended to remain within 60 nmi of the island during summer and winter, with adult animals foraging either in coastal fjords or in offshore gullies.

Food habits data collected in the Gulf of Alaska during the 1970s and 1980s have been further analyzed. These analyses indicate that juvenile walleye pollock (*Theragra chalcogramma*) were the major prey of Steller sea lions in the Gulf of Alaska for both juvenile (<4 years old) and adult sea lions in five of six subareas analyzed. Prerecruit pollock constituted a major part of the pollock preyed upon in the Gulf of Alaska

in both the 1975-78 (mean fork length (FL) = 29.8 cm) and 1985-86 (mean FL = 25.4 cm) sea lion collections. Small pollock appeared to have been more important for juvenile sea lions, which in 1985-86 consumed smaller fish (mean FL = 24.0 cm) than adult sea lions (mean FL = 27.9 cm).

In the Kodiak Island area, walleye pollock consumption increased from the 1970s to the 1980s. This increase was most apparent in juvenile sea lions where the proportion of animals which consumed pollock doubled from 38.2% to 75.0% of all collected juveniles with stomach contents. This increase in pollock consumption may have resulted both from increased abundance of small pollock in 1985-86 (due to the large 1984 year class), and decreases in abundance of other small forage fish. Between 1975-78 and 1985-86 the number of fish species consumed by Kodiak-area juvenile sea lions fell from eight to four, and the proportion of juvenile animals consuming nongadid species (mostly small schooling and demersal fish) fell from 44.0% to 25.0%. The apparent decline of alternative fish prey coupled with the generally low abundance of prerecruit pollock throughout most of the 1980s may explain part of the decline in sea lion abundance observed in the Gulf of Alaska in the 1980s.

Steller sea lion scats were collected in the Aleutian Islands region during 1990-93 by NMML and the U.S. Fish and Wildlife Service (USFWS) at rookeries and haul-out sites in the area between Ugamak Island (in the eastern Aleutian Islands) and Agattu Island (in the western Aleutian Islands) during both summer and winter. Atka mackerel (*Pleurogrammus monopterygius*) was found in 149 (91.4%) of 163 samples analyzed to date. The only other species commonly found were walleye pollock (12.3%) and Pacific salmon (*Oncorhynchus* spp.; 12.8%). Atka mackerel was common in the diet throughout the Aleutian Islands and increased from 69.6% (16 of 23 samples) in the eastern Aleutian Islands to 91.0% (61 of 67 samples) in the central Aleutian Islands and 98.6% (72 of 73 samples) in the western Aleutian Islands. The proportion of scats containing pollock remains decreased in a reverse fashion from 17.3% in the east to 8.2% in the west. There is little data on the historical importance of Atka mackerel as a prey item. The one Aleutian Islands site where comparable data exists prior to 1990 (Ugamak Island in the eastern Aleutian Islands) had no Atka mackerel remains in 11 scats collected in 1985, although all contained gadid remains. By 1991, mackerel was found in all scats collected (n=10), but only 1 had gadid remains. This shift parallels changes in the biomass of Atka mackerel and of walleye pollock during 1983-91.

The NMFS has conducted echo integration-midwater trawl surveys to assess Steller sea lion prey availability within 10 nmi of three rookeries (Marmot, Atkins, and Akun Islands) and one haul-out site (Cape Sarichef) during winter and summer 1992-93. Preliminary results indicated little fish biomass in the water column in these areas, although large swarms of euphausiids and occasional concentrations of 0-age cod were found.

California Current Ecosystem Program

Northern Fur Seals

The northern fur seal population at San Miguel Island, California, continued to increase in 1992 and 1993. Live pup counts conducted in Adams Cove and Castle Rock yielded total counts of 1,590 pups in 1992 and 2,045 pups in 1993. The 1993 count represents the highest number of pups counted since the colony was discovered in 1968 and indicates that the northern fur seal population at San Miguel Island has finally recovered from the devastating effects of the 1982-83 El Niño, which reduced pup production by 60% in 1983.

In January 1992, El Niño conditions prevailed along the California, Washington, and Oregon coast and continued through the summer of 1993. The effects of the 1992-93 El Niño were observed as high mortality rates of pups in 1992 and low weights of pups at 3 months of age in both years. However, the high pup production and greater mean weights of both sexes relative to the mean weights of pups during the 1982-83 El Niño suggest that the 1992-93 El Niño was not as detrimental to the health or survival of adult females as the 1982-83 El Niño event. This is probably because the onset of the 1992-93 El Niño in the Southern California Bight occurred in January 1992 and probably did not affect adult female survival since female fur seals had migrated out of the affected area before the environmental changes occurred. It appears from the pup production in 1992 and 1993 that females were able to forage adequately during the winter which resulted in successful reproduction in the 1992 and 1993 pupping season. Survival of the 1992 and 1993 cohorts, which weaned at lower than normal weights, will not be known until the pups return as juveniles 2 or 3 years later.

In 1975, long-term studies of behavior and survival of individual fur seals in the San Miguel Island population were initiated. In 1992 and 1993, 300 and 290 pups were tagged in each year, respectively, to continue these studies. Efforts to resight tagged individuals resulted in sightings of 220 individuals during the summers of the 2-year period. The oldest female sighted with a pup was 17 years old. Tag recoveries along the California, Oregon, and Washington coast and in commercial fisheries provide useful information on movements of individuals once they leave San Miguel Island. A female pup tagged in 1990 at San Miguel Island was recovered in the high-seas driftnet fishery in the North Pacific Ocean on 3 July 1991 at lat. 42°00'N and long. 161°04'W, providing the first data on mid-Pacific movements of pups born on San Miguel Island.

California Sea Lions

San Miguel Island, California

Studies of the population dynamics of the California sea lion (*Zalophus californianus*) population at San Miguel Island have been conducted since 1972. Each year live pup counts are conducted and are used as an index of the growth of the population. A total of 11,558 and 13,385 pups were counted in 1992 and 1993, respectively. The pup mortality rate in 1992 was high (at least 33%) and in 1993 was considerably lower (19%). The 1992-93 El Niño conditions along the coast of California contributed to the observed high mortality rate in 1992.

In 1992 and 1993, studies of the foraging ecology of adult female sea lions at San Miguel Island were continued from 1991, with satellite tagging of six adult females in May 1992 and six females in January in 1993. Preliminary analysis of the foraging ecology data indicates that adult females feed primarily along the central and northern California coast over the continental shelf, the continental shelf slope, and in deep water west of the continental shelf break during the winter and spring seasons (January-May). Females foraged an average northward distance of 110 km and 200 km from San Miguel Island in 1992 and 1993, respectively, and over 200 km west of the mainland in both years. Diving data revealed that females dove to depths greater than 450 m, deeper than has ever been reported for California sea lion females. Primary prey from the collection of scats during the winter and spring for the same years consisted of market squid (*Loligo opalescens*), Pacific whiting (*Merluccius productus*) and rockfish (*Sebastes* spp.). The results of this study may be confounded by the effects of El Niño conditions along the California coast beginning in January 1992 and extending through the summer of 1993. These conditions may have caused changes in prey distribution which may have affected the foraging distribution of females throughout 1992 and 1993. To better interpret these results, this study will be continued in the winter and spring of 1994.

Additional studies of the causes of mortality and immuno-suppression in California sea lion pups were conducted during summer 1992. These studies are part of the NOAA Southern California Damage Assessment Program, and the data are still being analyzed.

Oregon and Washington

Each winter, California sea lion males leave the breeding rookeries in southern California and migrate to the offshore islands and waters of Oregon and Washington. Males begin arriving in September, and the abundance peaks from February through April. Each year, aerial and boat surveys are conducted throughout the winter in cooperation with

the Washington Department of Fish and Wildlife (WDFW) and the Oregon Department of Fish and Wildlife (ODFW) to estimate the abundance of animals. In 1992 and 1993, the peak number of California sea lion males in Washington State waters was 642 and 627, respectively. In Washington, the peak number of California sea lions occurs in April prior to the southward migration of animals to the breeding rookeries in California. In Oregon, 5,461 California sea lions were counted in 1992 during the northward fall migration of male sea lions.

Harbor Seals

In 1992 and 1993, NMML, the WDFW, and the ODFW conducted cooperative aerial surveys of harbor seals for a long-term study of trends in abundance and pup production. Surveys were flown over the coastal estuaries, outer coast, Puget Sound, and Hood Canal in Washington, and outer coast and coastal estuaries of Oregon.

Also in 1992, in two areas of Oregon (the Umpqua River and Tillamook Bay) and in two areas of Northern Puget Sound (San Juan Islands, Washington, and Gulf Islands and Boundary Bay, British Columbia), 92 VHF radio transmitters attached to flipper tags were applied to harbor seals. 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 and Oregon. Coefficients of variation (CV) for abundance estimates were determined for multiple surveys and were found to be 0.25 or less in all cases. For Washington, a mean count of 20,898 harbor seals was obtained during the pupping season. The correction factor, based on the proportion of radio-tagged harbor seals ashore during surveys at six sites in Washington and Oregon, ranged from 1.3 to 1.8. The corrected statewide estimate was 28,284-38,060 harbor seals in Washington in 1992. For Oregon, a mean count of 6,605 seals was obtained during the pupping season. (Because of unfavorable survey conditions, no censuses were conducted during the postbreeding peak.) The corrected estimate accounting for seals in the water during surveys was 9,049-11,884 harbor seals in Oregon in 1992.

In 1993, NMML, in cooperation with the WDFW, conducted studies on harbor seal haul-out behavior and foraging and food habits in south Puget Sound. A pilot study of foraging behavior of adult females during the breeding season was initiated. For this study we attached TDRs on three adult lactating females to evaluate diving behavior and VHF transmitters to determine foraging locations. Scat samples were collected monthly at the study sites for food habits analysis. In addition, a long-term study on population dynamics was initiated using branded animals. Thirty-nine seals were branded in 1993.

As part of the MMPA stock assessment, NMML, the WDFW, and the ODFW collected skin samples for genetic studies to differentiate stocks within the harbor seal population. The samples were collected from the

rear flipper of live animals. Seals were sampled in Washington (Hood Canal, Puget Sound, and coastal estuaries), Oregon, and California. The skin samples for mt-DNA analysis were analyzed by LGL Ecological Research, Bryan, Texas. Preliminary results, relying on small sample sizes, indicate three stocks of harbor seals: one on the coast of Washington and Oregon, one in the inland waters of Washington, and one in California.

Northern Elephant Seals

Adult elephant seals (*Mirounga angustirostris*) on San Miguel Island, California, spend only 2-4 months on land each year: 1-3 months during the breeding season and 1 month during the molt. The remaining 8-10 months the animals spend at sea. The pelagic distribution of adult elephant seals is unknown. Collaborative studies of foraging and diving behavior have been conducted with Hubbs-Sea World Research Institute. Over 100 microprocessor-controlled location and dive recorders were deployed on adult male and female elephant seals following the breeding and molting seasons from 1989 through 1992. Instruments were recovered when the animals returned to shore. Adult females were at sea for about 70 and 230 days following breeding and molt seasons, respectively, whereas adult males were at sea for about 125 days following both the breeding and molt seasons. Females completed two migrations to pelagic foraging areas between lat. 40° and 45°N each year, and males migrated twice each year to foraging areas in the Gulf of Alaska or the Aleutian Islands region. Males and females forage in these discrete areas traveling 4,000-5,000 km (females) and 6,000-8,000 km (males) during each migration. Unlike other mammals, adult elephant seals undergo two migrations each year.

While at sea, elephant seals dive almost continuously. For over 350,000 recorded dives, the animals were submerged about 90% of the time. Dives averaged 21-25 minutes, with the longest dive lasting 119 minutes. Maximum depths of dives averaged 350-550 m, with the deepest dive being 1,529 m. Through the results of these studies, it has become clear that adult elephant seals from the California Channel Islands forage in mesopelagic communities in open ocean areas to accumulate energy in the form of blubber to carry out terrestrial reproductive and molt activities.

Harbor Porpoise

Incidental Take in Washington State

The incidental take of harbor porpoise (*Phocoena phocoena*) in the Makah northern Washington marine set-net fishery was monitored annually from May through September 1988-93. The estimated take has dropped substantially since 1988 (n=102) when this fishery was first monitored: 1989 (n=23), 1990 (n=13), 1991 (n=15), 1992 (n=2), and 1993

($n=0$). This decline is attributed primarily to a dramatic reduction in fishing effort by the Makah Tribe for chinook salmon (*Oncorhynchus tshawytscha*) due to the low abundance of chinook salmon in recent years.

Population Assessment

In collaboration with Cascadia Research Collective, NMML scientists conducted a calibration study in Washington, Oregon, and northern California during August 1992 using a team of shore-based observers to track porpoise groups that were being observed from an aircraft. The resulting data from this study allowed estimation of a correction factor (CF) to correct population estimates for the number of harbor porpoise missed along the aerial trackline. This empirically derived factor ($CF = 3.1$, $SE = 0.048$) has been applied to 1990-91 abundance estimates for harbor porpoise in the waters of northern California (Crescent City) north to southern British Columbia (northern Puget Sound and the Strait of Juan de Fuca). The corrected estimate of the minimum population size (lower 95% confidence interval) for the outer coast (Oregon and Washington) is 16,700 ($CV = 0.21$) while for the inside waters of Washington and British Columbia (Strait of Juan de Fuca and Puget Sound) is 2,700 ($CV = .27$). No harbor porpoise were seen during surveys in southern Puget Sound (south of Whidbey Island), which supports the suggestion that harbor porpoise are uncommon in that area of Puget Sound.

Stock Discretion

Two studies pertaining to harbor porpoise stock discrimination in Washington, Oregon, and northern California continued during 1992-93. Skin samples from 81 harbor porpoise, collected from California to Alaska, were analyzed at the SWFSC using mt-DNA and Polymerase Chain Reaction (PCR) sequencing techniques. Thus far, results indicate that two distinct groupings of haplotypes were found for northeast Pacific harbor porpoise, but there was no evidence of any geographic separation. One possibility is that two allopatric populations existed in the geologic past, possibly separated by ice, and are now currently mixing and interbreeding. More sensitive techniques are being developed which may provide information on the existence of recent geographic boundaries which may delineate stocks. A second study, using organochlorine pollutant residue levels in the blubber of harbor porpoise, was also continued in 1992 and 1993 with the collection of blubber from stranded and incidentally caught harbor porpoise along the Pacific coast. The results from the laboratory analysis of these samples are being analyzed.

Coastal Delphinids

Aerial population assessment surveys were conducted on dolphins during March-May of 1992 in the offshore waters of Oregon and Washing-

ton. The two primary species of concern were the Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) and Risso's dolphin (*Grampus griseus*). For Pacific white-sided dolphins, the population estimates ranged from 9,358 to 23,407 depending on whether the sample was stratified or not. For Risso's dolphins, the estimates ranged from 7,927 to 11,353. These estimates must be viewed with caution since they were obtained during an El Niño year of warm oceanic currents which may have altered the normal distribution of the coastal populations of these dolphins. No field studies were conducted in delphinids during 1993.

Population and Ecosystem Assessment Program

The activities of the Population and Ecosystem Assessment Program during 1992-93 included cooperative efforts involving other programs within NMML. Those activities, such as the northern fur seal population assessment, are reported elsewhere in the NMML section. Other activities involved provision of scientific support to the IWC, contributions to ecosystem level management, and assessment of incidental take of marine mammals in commercial fisheries.

Incidental Take of Marine Mammals in Domestic Groundfish Fisheries in Alaska

United States fisheries observers placed on vessels in the domestic groundfish fisheries in the U.S. Exclusive Economic Zone (EEZ) in Alaska during 1992 and 1993 reported the number of marine mammals caught in trawl, longline, and pot fishing gear. A total of 47 (1992) and 20 (1993) marine mammals of nine species were observed to have died incidental to fishing operations in 1992-93; 15 (1992) and 5 (1993) of these observed animals were Steller sea lions. A total of 21 Steller sea lions was estimated to have died incidentally in trawl fishing operations in these fisheries during 1992, which was higher than the average annual total estimated incidental mortality of 18 Steller sea lions for 1990-91 in domestic groundfish trawl fisheries in Alaska. The estimated total incidental mortality level of Steller sea lions for 1993 was eight animals, which was lower than the estimated total for each of the previous 3 years. Eight sea otters (*Enhydra lutris*) and one harbor seal died in pot fishing gear in the Bering Sea in 1992, which was the only year such incidental takes are known to have occurred.

Entanglement of Northern Fur Seals

During July and early August of 1992, entanglement of juvenile male northern fur seals in marine debris was studied on St. Paul Island, Alaska, in the Bering Sea. Estimates of entanglement-caused mortality, incidence of entanglement, and the kinds and sizes of debris were

determined. The proportion of entangled seals observed in 1992 (0.29%) was greater than in 1991 but was comparable to that observed during the previous several years. The entanglement rate since 1987 has remained lower than that observed during 1967-86. The 1992 studies confirmed earlier estimates that the annual survival of seals entangled in small debris is about one-half that of nonentangled seals. Seals from which debris was removed had significantly higher survival rates than those which remained entangled. During the 1992 roundups, 10 entangled male seals too large to be part of the entanglement study were captured and the debris was removed. No roundups were conducted in 1993.

Studies of Growth, Fasting, and Homing Behavior of Juvenile Male Northern Fur Seals

Body growth, fasting, and homing behavior of juvenile male northern fur seals were investigated using a large number of males which were tagged and weighed at their natal areas as pups during 1987-90. Information on growth of individuals between years, loss of body mass during fasting, and rate of return to the natal area were analyzed. Studies on survival rates and effectiveness of a modified metal monel tag are ongoing.

During roundups of juvenile male northern fur seals, data were collected on the growth of these seals, their homing tendencies and survival, and retention of a modified monel tag. Individuals were observed and weighed repeatedly in roundups at known locations so that growth rates and return rates to areas near the rookery where they were tagged could be measured. The results of these studies have been published in a variety of reports and papers.

Entanglement Among Adult Female Northern Fur Seals.

In both 1992 and 1993, adult females on St. Paul Island breeding rookeries were counted to determine the incidence of entanglement in marine debris. These data are used to monitor any changes in entanglement that may occur between years. Repeated counts were conducted on Reef Rookery to monitor seasonal change in entanglement among adult females. Results indicate that there is an increasing incidence of entanglement from early July to early August.

Ecosystem Management

On 16-18 September 1992, a workshop was held at Woods Hole, Massachusetts, to develop plans for a symposium on ecosystem management. This workshop, led by a NMFS steering committee with members from all five regional fisheries research centers, was attended by 10 NMFS

scientists and 10 invited participants. Members of the Population and Ecosystem Assessment Program coordinated the workshop. A report, including the proposal for an ecosystem symposium, is available at the NMML.

U.S.-Russia Marine Mammal Projects

In 1992, the U.S.-U.S.S.R. Environmental Protection Agreement (later to be known as the U.S.-Russia agreement) entered a period of transition. Although the project leadership on the Russian side still remains in VNIRO (Moscow) and works through the Ministry of Protection of the Environment and Natural Resources, a great deal more autonomy has developed among the regional Research Institutes for Fisheries and Oceanography (e.g., TINRO-Vladivostok, KOTINRO-Petropavlovsk-Kamchatskiy, and MOTINRO-Magadan).

The goal of the cooperative research program is to study the biology, ecology, and population dynamics of marine mammals of interest to both countries and to foster effective management of these animals. In 1992, the project facilitated the scientific exchange of five American researchers to Russia in two separate studies, and nine Russian scientists to the United States in five studies. The work included: 1) ecological studies of larga seals (*Phoca largha*) in Kamchatka; 2) sea otter community studies in the Commander Islands, Russia, and tooth structure and morphology in the United States; 3) research on Steller sea lions and harbor seals in Alaska; 4) data analysis and manuscript preparation of joint work conducted on walrus (*Odobenus rosmarus*) in 1990 and 1991, and 5) the first international northern fur seal workshop on population monitoring and evaluation of factors influencing population change (April 1992, Seattle) that included representatives from VNIRO (Moscow) and KOTINRO (Kamchatka).

In 1993, we conducted two joint studies including 3 U.S. scientists in Russia for larga seal and tooth structure studies and 16 Russians involved in four major activities in the United States. The latter included the Fourth International Sea Otter Workshop and the 12th project meeting in Anchorage. Additionally, four of the scientists participated in the Biennial Marine Mammal Conference in Galveston, Texas, and two of them presented papers there. A Russian scientist from KOTINRO carried out extensive fur seal data analysis and manuscript preparation during two visits in February and November of 1993.

For 1994, the project has tentatively agreed on more than 20 joint activities, including eight studies on sea otters, four on Steller sea lions, five on larga and other seals, two on walrus, and five activities on cetaceans (primarily work on gray whales, but also right and bowhead whales, and review of past whaling records).

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION

The Resource Assessment and Conservation Engineering (RACE) Division continued its program of resource assessment to provide scientific information for the management of marine fish and shellfish. During 1992-93, major resource assessment surveys were conducted in the Gulf of Alaska, the Bering Sea, and waters off the West Coast. In research designed to help reduce the bycatch of prohibited or unwanted fish and crab, special purpose surveys were also conducted in waters near Kodiak Island. This research examined fish behavior in and around trawls and crab behavior in and around crab pots. Research continued on recruitment processes through the Fisheries-Oceanography Coordinated Investigations (FOCI) study in Shelikof Strait and expanded these studies to the Bering Sea. In addition, studies on fisheries pathology, ecology, acoustics, and gear performance were also conducted. All of the above activities were supported by RACE data management and gear maintenance groups.

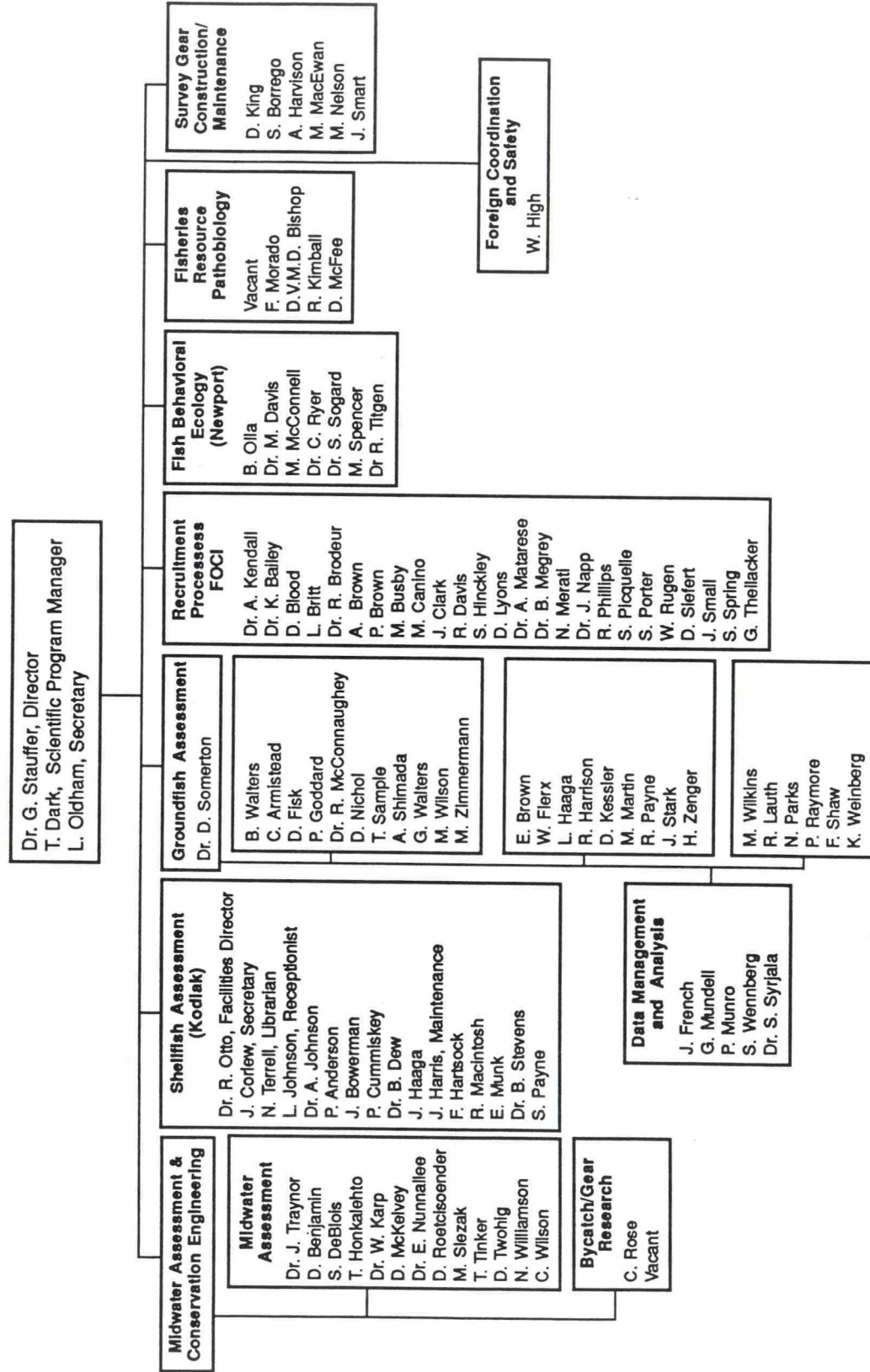
Groundfish Assessment

Bering Sea Groundfish Assessment

The Bering Sea Groundfish Subtask, in association with the Shellfish Assessment Program in Kodiak, completed bottom trawl surveys of the eastern Bering Sea in 1992 and 1993. The primary purpose was to assess the biological condition of important fish and shellfish species. These surveys were a continuation of a series of annual assessment surveys that began in the early 1970s. Since 1979, the surveys have included a standard area encompassing approximately 465,000 km², including eastern Bering Sea continental shelf waters from inner Bristol Bay west to the 200-m depth contour and from the Alaska Peninsula north to St. Matthew Island. Additional sites north of the standard area were also sampled to assess the condition of snow (Tanner) crab (*Chionoecetes opilio*). Each survey was conducted aboard two chartered fishing trawlers from 1 June to mid-August.

Results from the two surveys indicate stable abundance levels for most important commercial groundfish species. Walleye pollock (*Theragra chalcogramma*), historically the most abundant groundfish species in the eastern Bering Sea, had an estimated biomass of 4.3 million metric tons (t) and 5.5 million t in 1992 and 1993, respectively. Pollock biomass estimates have ranged from a low of 2.9 million t in 1982 to a high of 7.1

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION ORGANIZATION CHART 1992-93



million t in 1990, but estimates have remained fairly stable since 1983. Declines in the abundance of the fishable stock, largely composed of strong 1978, 1982, and 1984 year classes, have occurred. However, recent trawl surveys and analyses have indicated the presence of a strong 1989 year class which should contribute significantly to the population. Pacific cod (*Gadus macrocephalus*) biomass was estimated at 546,700 t in 1992 and 690,500 t in 1993. These figures indicate relatively little change in total biomass since 1990 but may still be considered depressed when compared with 1981-89 annual estimates which were near 1 million t. Yellowfin sole (*Pleuronectes asper*) abundance has remained at a remarkably stable level since the mid-1980s. Biomass estimates from 1992 and 1993 were 2.2 million t and 2.5 million t, respectively. Rock sole (*Pleuronectes bilineatus*) have shown a significant increase in biomass from 1.6 million t in 1992 to 2.1 million t in 1993. Rock sole abundance has steadily increased, tripling in biomass since 1983. Arrowtooth flounder (*Atheresthes stomias*) and flathead sole (*Hippoglossoides elassodon*) both exhibited peak biomass levels within the last two surveys. Arrowtooth flounder reached a peak biomass of 543,600 t in 1993, compared with 414,000 t in 1992. Flathead sole attained a peak biomass of 650,100 t in 1992 and has remained high (610,000 t in 1993). Alaska plaice (*Pleuronectes quadrituberculatus*) estimates have remained somewhat stable, with annual biomass estimates ranging between 699,000 and 800,000 t since 1982. Alaska plaice biomass estimates for 1992 and 1993 were 549,700 t and 515,200 t, respectively. Greenland turbot (*Reinhardtius hippoglossoides*) experienced a dramatic decline in biomass over the standard shelf area (due to poor recruitment) from 1979 (225,600 t) to 1986 (5,600 t). This species has shown some evidence of recovery, as indicated by biomass estimates of 24,000 t and 30,400 t in 1992 and 1993, respectively.

In 1992, a U.S.-Russian bottom trawl survey of the western Bering Sea was also conducted. The survey was a continuation of cooperative assessment surveys of groundfish resources in the Bering Sea by scientists from the AFSC and the Pacific Research Institute of Fisheries and Oceanography (TINRO) of the Russian Federation. The survey was conducted aboard the Russian research vessel *Mys Babushkina* and encompassed the Gulf of Anadyr and continental shelf waters from Cape Olyutorski to the U.S.-U.S.S.R. Convention Line of 1967.

Gulf of Alaska/Aleutian Islands Groundfish Assessment

Trawl Surveys

The fourth comprehensive triennial bottom trawl survey of western and central Gulf of Alaska groundfish resources was conducted between 2 June and 8 September 1993 aboard three chartered commercial trawlers. The main objective of the survey was to describe the distribution, abundance, and biological condition of various Gulf of Alaska groundfish stocks.

A stratified random sampling design developed in 1984 was used for the 1993 survey. The continental shelf region was divided into 24 sampling strata based primarily on the 100- and 200-m depth contours and geographical features such as banks, gullies, and flats. The 100-200 m, 200-300 m, and 300-500 m depth intervals, which form narrow bands along the outer edge of the continental shelf, were divided into four strata each according to International North Pacific Fisheries Commission (INPFC) statistical boundaries. A total of 748 preselected stations were randomly selected for the survey, but not all sites were sampled, primarily due to unsuitable bottom conditions. Successful trawls were achieved at 623 of the 674 stations attempted, at depths ranging from 20 to 513 m, an increase of 23% over the 508 stations completed during the 1990 survey.

Arrowtooth flounder had, by far, the highest abundance of any species (1.4 million t) but was down approximately 21% from the 1990 triennial survey. Walleye pollock, with a biomass of 750,000 t, was similar in abundance to 1990 estimates but showed a major shift in biomass distribution from the Kodiak INPFC area to the Shumagin INPFC area.

Species exhibiting large, apparent increases in abundance included Pacific halibut (*Hippoglossus stenolepis*), up 77% from 1990 to 558,000 t, and Pacific ocean perch (*Sebastes alutus*), up 472% to 338,000 t. Several other rockfish species, including rougheye (*S. aleutianus*) and shortraker (*S. borealis*) rockfish and shortspine thornyhead (*Sebastolobus alascanus*), also showed large increases from the 1990 survey. The abundance of sablefish (*Anoplopoma fimbria*), 213,000 t, and rock sole, 181,000 t, increased moderately from 1990.

In addition to arrowtooth flounder, other species showing decreases in abundance were flathead sole, down 22%; rex sole (*Errex zachirus*), down 17%; and Dover sole (*Microstomus pacificus*) and Atka mackerel (*Pleurogrammus monopterygius*), down 35% and 33%, respectively. Pacific cod, 405,000 t, and northern rockfish (*Sebastes polyspinus*), 111,150 t had the least change in abundance.

Longline Surveys

The sixth and seventh annual NMFS longline surveys of the upper continental slope and deep gullies of the Gulf of Alaska were conducted by the RACE Division in cooperation with the Center's Auke Bay Laboratory from July to September in 1992 and 1993. The primary objectives were to determine the relative abundance and size compositions of sablefish, shortspine thornyhead, and shortraker rockfish and rougheye rockfish. One hundred twenty-four longline sets were completed at 63 pre-established stations distributed between the Islands of Four Mountains (long. 170°W) and Dixon Entrance. Forty-seven of these stations have been sampled annually since 1979 by the Japan-U.S. cooperative longline survey, the forerunner of the NMFS survey.

Sablefish abundance estimates for the western and central Gulf of Alaska upper continental slope region decreased between 1990 and 1992 but recovered slightly in 1993. Sablefish abundance estimates for the eastern gulf increased steadily from 1988 to 1992 and decreased slightly in 1993. Total sablefish abundance on the upper continental slope appears to be the highest since the NMFS longline survey began in 1988. Sampled gully areas have shown considerable variability in sablefish abundance. The presence of sablefish in the gullies was highest between 1989 and 1991. Generally, sablefish move out of the deep gullies to the upper continental slope as they approach maturity. Higher than average sablefish abundance in the gullies suggests future higher than average recruitment to the fisheries that traditionally have been conducted on the upper slope.

During the summers of 1992 and 1993, the 14th and 15th annual Japan-U.S. cooperative longline surveys were conducted in the Bering Sea/Aleutian Islands region and the Gulf of Alaska. Sablefish abundance has been declining most notably in the Bering Sea/Aleutian Islands region since 1986. 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%. Since 1990 each survey has shown relatively little change in gulfwide sablefish abundance on the upper continental slope, but the cooperative survey has reflected relative population levels about 25% lower than those of the NMFS survey. Catch per unit effort (CPUE) comparison studies show that while the surveys yield different catch rates (NMFS CPUE is higher), their relative fishing powers have remained much the same since 1990.

West Coast Groundfish Assessment

The West Coast Groundfish Subtask continued its series of triennial bottom trawl surveys of the groundfish resources off California, Oregon, Washington, and British Columbia during the summer of 1992. The survey began 13 July near Pt. Conception, California, (lat. 34°30'N) and concluded on 10 October off Nootka Sound, British Columbia (lat. 49°30'N). Two chartered vessels successfully completed trawl hauls at 526 of the scheduled 601 stations between the depths of 55 and 366 m. The West Coast triennial survey series dates back to 1977. In the earlier surveys (1977-86), the survey design emphasized providing estimates of rockfish abundance for resource management. Experience from those surveys showed that area-swept trawl surveys did not provide sufficiently precise rockfish abundance estimates because of the highly patchy distribution of rockfish. The survey design was altered in 1989 to emphasize multispecies objectives and to improve the precision of Pacific whiting (also known as Pacific hake) (*Merluccius productus*) and sablefish biomass estimates. The 1992 survey replicated the 1989 survey design.

A mild El Niño event occurred during the 1992 survey, which caused some apparent changes in the distribution of coastwide species. Pacific whiting and sablefish biomass estimates, while as large or larger than in 1989 for the total survey area, were much smaller for the more southern INPFC statistical areas. The 1992 collection of temperature profiles at all stations and conductivity-temperature-depth (CTD) casts at more than 100 stations were the most comprehensive to date. The relationships (if any) between the shifts in distribution and observed temperature anomalies are being studied.

The West Coast continental slope bottom trawl survey series was continued during 1992 and 1993. Two comprehensive surveys of these resources were conducted in the area between the U.S.-Canada border and Cape Blanco, Oregon, (lat. 42°50'N) at depths between 183 and 1,280 m. The West Coast slope survey dates back to 1984, when it was conducted to 1) provide a benchmark of the distribution and abundance of sablefish, Dover sole, thornyheads, and arrowtooth flounder stocks off the central coast of Oregon and 2) obtain information on these species' population biology. The 1992 survey (17 October to 11 November) successfully collected trawl samples at 78 stations, and the 1993 survey (12 October to 12 November) successfully sampled 125 stations.

Survey results show that Dover sole catch rates in 1992 and 1993 were highest in the shallowest stratum and decreased with depth. In contrast to other surveys, however, the highest sablefish catch rates were seen in the shallowest stratum. Usually this species is more abundant in the middle depth strata of this type of survey. The two thornyhead species exhibited their typical overlapping depth distributions with shortspine thornyhead dominating the two shallower strata, eventually being displaced by longspine thornyhead (*Sebastolobus altivelis*) in the deeper strata. Arrowtooth flounder catch rates were higher than those seen in more southern areas, although this was expected since the survey area is near the southern extent of this species' range. Snow (Tanner) crab catch rates were also generally consistent with earlier years, but with a slightly higher proportion of crabs in the two deepest strata.

Midwater Assessment and Conservation Engineering

Bering Sea Walleye Pollock Surveys

From 25 February to 8 March 1992, U.S. scientists from the Midwater Assessment and Conservation Engineering (MACE) program conducted an echo-integration trawl (EIT) survey of the southeastern Aleutian basin and the southeastern Bering Sea shelf to assess walleye pollock abundance. East of long. 164°45'W on the shelf, pollock echo sign was on or near bottom. Trawl hauls revealed that these aggregations were composed of large adult pollock (40-65 cm). West of long. 164°45'W,

dense pollock aggregations were encountered in midwater. These fish were smaller, ranging from 30 to 40 cm. No active spawning was observed on the shelf, although most of the large adult pollock were in a prespawning (mature) reproductive state. Pollock biomass estimates for the shelf region surveyed in 1992 were 0.3 million t. Near Bogoslof Island, dense layers of pollock echo sign were observed at 400-500 m. Trawl hauls caught pollock 40-60 cm in length. The majority of the fish were in a late prespawning stage, but by the survey's end on 8 March very few had spawned. Spawning timing appeared late when contrasted with previous years. Analysis of the acoustic data for the Bogoslof Island area indicated that pollock biomass was 0.9 million t, a decline from the winter 1991 estimate of 1.3 million t.

In 1993, the EIT survey area was expanded beyond the Aleutian basin and Bering Sea shelf waters of the U.S. Exclusive Economic Zone (EEZ) to include western Bering Sea waters. The 1993 winter EIT survey was part of an international survey effort involving scientists from Japan, Russia, China, Poland, and the Republic of Korea. Between 7 January and 14 March, Japanese scientists aboard a Japanese research vessel surveyed the deeper Aleutian basin waters east and west of the U.S./Russia Convention Line, including the "Donut Hole." Outside the Bogoslof Island region, they encountered very little pollock echo sign in the Aleutian basin. MACE scientists aboard the NOAA research vessel *Miller Freeman* surveyed the ice-free portion of the western Bering Sea shelf from Cape Ozernoi (lat. 56°N) to midway between Cape Olyutorsky and Cape Navarin (lat. 61°N) on 14-23 February. Pollock abundance was low (0.2 million t) compared with that observed in U.S. EEZ waters, and 90% was in the region southwest of Cape Olyutorsky.

In the Bogoslof Island region, surveyed 27 February to 5 March, pollock echo sign was detected between 250 and 800 m. Spawning in the Bogoslof Island region probably peaked sometime during the second week of March. Estimated pollock biomass for the Bogoslof Island region was 0.6 million t. On the eastern Bering Sea shelf south of St. Paul Island surveyed 6-12 March, pollock with lengths 35-45 cm dominated the survey catch. Pollock greater than 45 cm were found in only one location near Unimak Island; otherwise, they occurred either on the slope or near the Pribilof Islands. No active spawning was observed. Spawning on the southeast shelf is thought to occur during late March and in April. Pollock on the shelf had a biomass of 2.3 million t.

Gulf of Alaska Walleye Pollock Surveys

The 11th annual EIT survey to assess the abundance of walleye pollock within Shelikof Strait in the Gulf of Alaska was conducted during the second half of March 1992. Several other areas within the gulf were also surveyed during the cruise but did not contain significant quantities of pollock. The distributional pattern of pollock within the Shelikof Strait

area was similar to that observed in previous years; mature fish were found throughout the area, although greatest densities were found along the northwest side of the northern portion of the strait and relatively large numbers of age-1 fish were observed in the southern region of the strait. The survey timing appeared to coincide with the peak spawning period. Historic age-length relationships and numeric and biomass size composition estimates suggested relatively low abundance of 2- and 3-year-old fish and high abundance of 4-year-old fish. These patterns are consistent with trends observed in recent years which indicate that the 1988 year class was comparatively strong and the two subsequent year classes were relatively weak. The biomass estimate for the 1992 Shelikof Strait pollock assessment was 681,000 t, which was slightly higher than for 1991.

In 1993, the annual Shelikof Strait EIT assessment survey of walleye pollock occurred during mid-March. No areas outside Shelikof Strait were surveyed. Pollock distributional patterns were similar to previous years. Most pollock echo sign was detected within 50 m of the substrate, and the greatest densities of mature prespawners were found along the northwest side of the northern region of the strait. No actively spawning females were observed in trawl catches. The 1993 abundance estimate of 408,000 t was about one-half the value reported in 1992. Since 1988, however, biomass estimates for the strait have remained low and stable compared with earlier years, and the results from 1993 continue this trend.

West Coast Pacific Whiting Survey

The sixth triennial EIT survey to assess the abundance and distribution of Pacific whiting was conducted during July to August 1992 in conjunction with the West Coast groundfish triennial bottom trawl survey. Survey operations extended from central California to the northern end of Vancouver Island, British Columbia, and extended across the continental shelf/upper slope between bottom depths of about 50-450 m. Operations were extended farther offshore in areas where commercial fishing operations had occurred in previous years and where echo sign was observed beyond the offshore limits of planned transects. As in previous surveys, greater average sizes and ages of fish were found in the more northerly areas covered during the survey. Thus, all age-1 and virtually all age-2 fish were found south of the Columbia River, whereas older fish, primarily the 1980, 1984, and 1987 year classes (5-, 8-, and 12-year-olds), dominated the population to the north. The total estimated biomass of Pacific whiting in midwater was 2.6 million t, of which the 1980, 1984, and 1987 year classes represented about 77% of the biomass and 64% of the population numbers. About 40% of the total coastwide biomass was found in the offshore region characterized by bottom depths greater than 450 m. This offshore biomass contribution may explain the increase in abundance reported between the 1992 and 1989 triennial estimates.

Conservation Engineering and Bycatch

The Conservation Engineering group within the MACE program has continued its work to determine the effects of variability in the operating dimensions of bottom trawls on survey results. While variation in the area of seafloor swept by survey trawls has been compensated for by using measurements of trawl openings made with acoustic trawl measurement equipment, it has not been known whether variation in trawl shape changes the ability of the trawl to capture the fish in its path. An experiment was conducted in September 1993 to test for such a difference. The experiment consisted of comparison trawling at one site while adjusting trawl rigging to achieve alternating wide and narrow configurations. Results of this experiment indicated that the narrow configuration retained 10% more of the flatfish in its path than the wide configuration. The difference was even greater for pollock. The rigging adjustment used in this experiment, a line attached between the towing cables 100 m ahead of the trawl doors, shows some potential for reducing the trawl variability itself.

Work also continued in 1992 and 1993 on a project initiated in spring 1990, in cooperation with the International Pacific Halibut Commission and the fishing and fishing gear industries, to develop fishing gear technology capable of both effective fishing and reducing bycatch of Pacific halibut and other unwanted or prohibited species. An underwater video/sonar system developed in 1990-91 was used to observe the behavior of Pacific halibut, Pacific cod, and small flatfish in the vicinity of a range of modified trawls and unmodified nets. Results from this work in 1993 are particularly noteworthy because of the favorable results observed in a modified bottom trawl that shows promise for reducing the bycatch of Pacific halibut and Pacific cod in a trawl fishery for small species of flatfish.

In addition to this specific project, support has been provided to other bycatch reduction studies with *in situ* observation equipment and vessel time. This cooperative work has included trawl manufacturers, regional academic institutions, and the Canadian Department of Fisheries and Oceans.

Shellfish Research

Bering Sea Crab Assessment and Crab Fisheries

Calculations of abundance, distribution, and size composition for crab stocks are made annually from the eastern Bering Sea trawl survey data. (See Bering Sea Groundfish Assessment for a description of the survey.) The abundance index of legal male Bristol Bay red king crab (*Paralithodes camtschaticus*) has fluctuated over the past 3 years (1991-93). The general population trend is downward. The index for legal

males was 11.5 million in 1991, 4.9 million in 1992, and 7.3 million crab in 1993. Fortunately, the 1991-93 abundance of mature females has been more stable, ranging from 12 to 14 million crab and remaining well above the 8 million crab threshold, below which the fishery would be closed. Recruitment to the Bristol Bay stock has been generally declining since 1987. Indices for juvenile crabs are now the lowest on record.

For the first time, abundance of red king crab in the Pribilof Islands was considered high enough to justify opening a separate fishery for them in 1993. Abundance indices for legal males have been 100,000 in 1990, 500,000 in 1991, 800,000 in 1992, and 2.5 million crab in 1993. Abundance of red king crab exceeded that of blue king crab (*P. platypus*) in the Pribilof District for the first time since surveys were started in the region.

The abundance of legal male blue king crab in the Pribilof Islands has been stable but low. The index has been 1.0 million crab in each of the last 3 years (1991-93). The abundance index for legal males in the St. Matthew Island area was 2.2 million in 1991, 2.3 million in 1992, and 3.6 million crab in 1993. Assessment of recruitment is difficult because many sublegal crab inhabit untrawlable grounds near the island. Index values for sublegal males are, however, the highest on record, and legal male abundance will likely remain stable or increase in 1994.

Abundance indices for Tanner crab (*C. bairdi*) were extremely low in the mid-1980s, leading to fishery closures in 1986 and 1987. Abundance of legal males increased steadily thereafter and was 35.1 million in 1991 and 48.1 million in 1992 but declined sharply to 20.6 million legal males in 1993. There were high levels of juvenile abundance and good recruitment from 1987 to 1991, but juvenile abundance declined in 1992 and 1993. Current abundance of legal males, while near average, is likely to decline further.

Abundance of commercial-size snow crab (*C. opilio*) declined from a record high of 484.1 million crabs in 1991 to 256.4 million crabs in 1992 and further declined to 135.0 million crabs in 1993. Declining abundance was expected due to the passage of an extremely large cohort which supported record catches in 1988-91 fisheries. Further declines are expected, but abundance of juveniles is increasing and recruitment should improve in 2 to 4 years.

Shrimp Surveys

An annual fall survey of Pavlof and Volcano Bays on the south side of the Alaska Peninsula has been conducted since 1972 and is the longest continuous time series of shrimp stock assessment in Alaskan waters. While northern shrimp (*Pandalus borealis*) and other pandalids have been the historic focus of this survey, valuable catch data on finfish are also collected.

Pandalid shrimp biomass indices in Pavlof Bay averaged 44.1 million lb (20,000 t) from 1972 to 1977. During this time Pavlof Bay supported a major fishery and northern shrimp biomass averaged 19.5 million lb (8,850 t) or 43% of total pandalids. Most of the remainder was humpy shrimp (*P. goniurus*) and coonstripe shrimp (*P. hypsonotus*). From 1977 to 1979, pandalid shrimp biomass declined at an average rate of 84% per annum, from a peak index of 53.2 million lb (24,100 t) to only 1.4 million lb (640 t) in 1979. The fishery was closed in 1979. In the period from 1980 to 1993, the biomass indices for pandalid shrimps averaged only 640,000 lb, of which 98% were northern shrimp. Declines in shrimp biomass were hence accompanied by a drastic and fairly stable change in species composition. The pandalid biomass index in 1992 was 390,000 lb (180 t) and fell to a record low of only 140,000 lb (63 t) in 1993. In the past 2 years, the biomass of humpy and coonstripe shrimp has been negligible.

Juvenile Red King Crab Habitat Study

The Kodiak Island Borough contracted with the Kodiak Laboratory in 1991 and 1992 to investigate the suitability of Womens Bay, Trident Basin, and Anton Larsen Bay as juvenile red king crab habitat. While the borough's project was completed in 1992, research in Womens Bay continued in 1993 with respect to sonic tracking of aggregations of red king crab.

Of the three bays studied, Womens Bay had the highest abundance of juveniles, as determined by diver sampling, and a more variable temperature regime and higher habitat suitability scores. It was recommended that future enhancement efforts be concentrated in Womens Bay until the benefits of a given type of enhancement could be evaluated. Tracking of crabs with sonic tags during the study showed that residence time in Womens Bay includes the first 5 years (age 0-4) of life. Age 2-3 juveniles preferred shallow water and were frequently found near vertical structures such as pilings in winter. Sonic tagging showed that juvenile red king crabs in Womens Bay maintained discrete, age-specific aggregations for up to 25 months and confirms that they have highly aggregated, podding behavior at least until age 5.

Handling Mortality Research

During 1992 and 1993, the Kodiak Laboratory initiated studies on the indirect effects of crab fishing on crabs. There is concern that handling of nontarget crabs during crab fishing could cause significant mortality and result in diminished catches in subsequent years. Reports from Alaska Department of Fish and Game (ADF&G) observers in 1992 show that five to six non-target crabs were handled for each legal male landed.

In October 1992, experiments were conducted in cooperation with the ADF&G aboard the commercial crab vessel *Kristen Gail*. The purpose of the experiments was to determine the proportion of crabs captured by commercial crab pots that were injured, the types of injuries incurred, and the proportion of crabs with various types of injuries that subsequently died. A major purpose of these experiments was to obtain data for use in designing future studies on the effects of handling mortality.

Preliminary results from these experiments are viewed cautiously because experimental conditions were not optimal. However, results showed that

- Crabs ranged from 75 to 180 mm in length (red king crabs) or width (Tanner crabs), and almost all were males with hard shells.
- Most king crabs (85%) and Tanner crabs (73%) were apparently uninjured. The most frequent injuries were broken spine tips for king crab and damaged or autotomized legs for Tanner crab.
- The proportion of injured crabs increased with size for Tanner crab but was unrelated to size for king crab.
- When selected crabs were held in running seawater for 48 hr to estimate mortality rates for injured and uninjured crabs and these rates were multiplied by the proportion of each type observed in the catch, the estimated overall mortality rates were 5.2% for red king crab and 11.0% for Tanner crab.

We are also conducting other experiments concerning handling, as well as escape of crabs from pots.

In April 1993, a leased remotely operated vehicle (ROV) was used to test the feasibility of using this technology to observe interactions between crabs and both lost and actively fished pots. Crabs in pots tended to move into the current and to congregate in corners on the upstream side of the pot. This behavior may indicate that escape mesh or rings would be most effective if placed in the corners of pots.

Pharmaceuticals from Marine Invertebrates

Over 300 lb of marine invertebrates collected during 1992 and 1993 were shipped to six biomedical research laboratories interested in developing medicines from sea life. Shipments included echinoderms, bryozoans, coelenterates, tunicates, and sponges. Results have included identifi-

cation of compounds active against murine leukemia from several echinoderms, presence of a possible anti-hypertensive agent in the flat-bottomed sea star, and demonstration of an immunosuppressive agent in compound tunicates.

Undersea Research Projects

In 1992 and 1993, NOAA's National Undersea Research Program (NURP) continued support of undersea research near Kodiak begun in 1991. In May 1992, the submersible *Delta* revisited the site where large aggregations of mating Tanner crabs had been discovered in 1991. Unfortunately, most crabs had dispersed prior to this visit and only moderate densities of females were observed; however, they occurred within 100 m of the location where densely aggregated pods were found in 1991. The earlier dispersal may be attributable to warmer water temperatures found in 1992.

In April 1993, a leased ROV was used for 2.5 days to explore the area where mating Tanner crab concentrations had been observed in 1991-92 by submersible. Observations showed high concentrations of pod-forming females at distances 50-100 m from 1991 and 1992 locations. The 1993 observations hence supported the conclusion that aggregation and pod forming is an annual phenomenon that occurs repeatedly in nearly the same location.

Recruitment Processes

Fisheries-Oceanography Coordinated Investigations (FOCI), a NOAA cooperative research program between the Recruitment Processes Program 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. FOCI's focus is the well defined spawning population of walleye pollock in Shelikof Strait and, more recently, in the southeastern portion of the Bering Sea. The FOCI research is composed of field and laboratory studies, both of which are described below.

Field Studies

The FOCI program conducted two cruises aboard the NOAA research vessel *Miller Freeman* during early spring of 1992 and 1993 in the Shelikof Strait region of the Gulf of Alaska. These cruises concentrated

on the egg stage of walleye pollock and continued the long-term ichthyoplankton survey to determine the horizontal distribution and abundance of eggs. Samples of fish and invertebrates that are potential predators on pollock eggs were also collected. Eggs were stripped from adults for rearing in Seattle and Newport, Oregon, and in 1993 sediment traps were deployed to monitor eggs settling to the benthic layer. Preliminary counts of eggs from the 1993 field season indicated that they were less abundant and were located further north in Shelikof Strait than in previous years.

The Bering Sea cruises occurred immediately after the Shelikof Strait egg cruises in 1992 and 1993 and included hydrographic surveys to measure ocean currents affecting egg and larval transport. The surveys also determined horizontal and vertical distribution of larvae; facilitated collection of larval samples for feeding, growth, condition, and genetic studies; and facilitated collection of zooplankton and microzooplankton samples. Rough counts of larvae in 1993 indicated higher abundance than in 1992 and that high numbers of larvae coincided with an eddy-like feature. Also, larvae collected over the continental shelf were larger than larvae collected at offshore locations.

Four cruises during mid- to late spring 1992 and 1993 in Shelikof Strait concentrated on larval walleye pollock. Broad-scale surveys assessing larval abundance and sample collection for age/condition studies took place during the mid-spring cruises. Preliminary results of larval counts indicated that larvae were more dispersed in 1993 than in previous years. Rough counts of 1993 late-stage pollock larvae indicated that they were less abundant than in previous years.

During late spring, additional surveys were conducted for estimating larval distribution, drift, and mortality rates.

Hydroacoustic sampling was tested during the 1992 late spring cruise as a real-time method of detecting and defining eddies. Eddies are thought to enhance larval survival and, ultimately, recruitment by entraining larvae on the continental shelf rather than having the larvae advected out to deep water in the Gulf of Alaska. The MACE Program's Simrad EK500 echo sounding system revealed anomalous patterns made by the sound scatterers in several locations in Shelikof Strait. Three of these patterns were observed in satellite images to contain eddy-like features.

Laboratory Studies

In the spring of 1992 and 1993, scientists reared pollock larvae from fish that spawned in the Shelikof Strait and Bogoslof Island area to investigate: growth patterns of otoliths; effects of temperature on egg and early larval development; feeding, digestion, and gastric evacuation

rates; functional feeding response of first-feeding larvae; and condition indicators and growth rates of larvae.

Additionally, the biochemical indices section of FOCI continued research to develop tools for evaluating important traits of larval walleye pollock to help understand how larvae respond to a changing environment. Accomplishing this goal encompasses both laboratory and field work. In the laboratory, a major objective is to calibrate nutritional stress and relate the index to the probability of larval survival. In the field, the goal is to determine whether starvation is a source of larval mortality. Several indices have been developed to detect larval nutritional condition. For pollock in the Gulf of Alaska, a histological condition index based on the height of the midgut mucosal cells was developed in the laboratory and applied to the field. The application of this index to the field in 1992 revealed that first-feeding larval walleye pollock in Shelikof Strait were vulnerable to starvation.

The search is under way for other tools that could be used to identify larval condition on site to assist in planning sampling protocol at sea. Most of the research has been directed toward analyzing suspensions of pollock brain cells for RNA and DNA content using flow cytometry. Two indices of nutritional condition and growth were developed that are estimated simultaneously on individual fish. Nutritional condition was estimated from the fraction of brain cells that exhibited distinct RNA activity among larvae that were always fed, always starved, and starved before feeding. Fast and slow growing larvae were discerned by differences in their DNA synthetic activity.

Fisheries Behavioral Ecology

Laboratory studies of environmental factors which influence the distribution and survival of walleye pollock larvae and juveniles are conducted at the AFSC's experimental facilities at the Mark O. Hatfield Marine Science Center in Newport, Oregon. Experiments have shown that, in complete darkness, yolk-sac larvae are positively geotactic beginning at hatching and until first-feeding readiness, causing them to actively swim downward and remain in the lower layers of the water column. When developmentally able to feed, the larvae exhibit an ontogenetic switch in geotactic behavior and become negatively geotactic and swim into the upper, lighted layers of the water column where they can begin to feed. Yolk-sac larvae sampled in the Gulf of Alaska show trends in vertical distribution similar to those observed in the laboratory.

Behavioral studies on walleye pollock juveniles have shown that integration of multifactor environmental inputs acts to modify behavioral responses to particular factors and, thereby, determines juvenile distribution. For example, the presence of predators, high-intensity light, or low food abundance can modify the avoidance of cold temperatures by juveniles, causing them to increase residence time in cold water. Intrin-

sic factors such as reduced condition of fish may also modify behavioral responses to cold temperature. For example, when food is limited and condition is poor, juveniles reduce activity and increase avoidance of cold water.

Fisheries Resource Pathobiology

Systemic Ciliate Disease

The fourth year of the study on the molt-related mortalities of the Dungeness crab (*Cancer magister*) caused by a facultative parasitic ciliate (*Mesanophrys* sp.) was concluded in 1993. From 1990-1992, 654 Dungeness crabs were collected, of which 97 (14.8%) were found infected with *Mesanophrys*. Most of the infections occurred in recently molted crabs (64 of 164 or 39%), particularly in recently molted male crabs (59 of 137 or 43.1%). During the same survey period rock crabs (*C. productus*) and kelp crabs (*Pugettia producta*) were also found infected at rates of 3% (3 of 87) and 28.6% (2 of 7), respectively.

Studies on the taxonomy, culture, histopathology, and ultrastructure were also concluded in 1993. The results of these studies indicate that the Dungeness crab ciliate is an undescribed member of the genus *Mesanophrys*. The results further indicate that the ciliate 1) has many ultrastructural features in common with other members of the Order Scuticociliatida, 2) is an active feeder of both host hemocytes and tissue, and 3) is capable of surviving under a wide range of conditions. *In vitro* studies demonstrated that optimal growth occurred in a chemically defined medium that was incubated at 20°C and adjusted to pH 7.2 and specific gravity 1.020 (27‰ salinity).

Soft Muscle in Atlantic Salmon

Soft skeletal muscle has been encountered in many fish species and has generally been attributed to the presence of protistan parasites, especially microsporidians and myxosporeans. It is generally believed that these parasites release muscle proteases during their growth that cause a general softening of host skeletal muscle. However, protease production and release by myxosporean or microsporidian muscle parasites has not been verified. In 1993, a research program was started to examine the causes of skeletal muscle softening in net-pen reared Atlantic salmon (*Salmo salar*) in the Pacific Northwest. Preliminary results suggest that not all muscle softening can be attributed to the presence of either myxosporean or microsporidian parasites. Myxosporean parasites of the genus *Kudoa* were encountered but not in all affected fish and not at levels that would suggest a cause-and-effect relationship. While the observed prevalence is low, affected Atlantic salmon were

reported throughout the Pacific Northwest, indicating that this syndrome is widely distributed and could be of major economic importance if it continues. A more detailed epizootiological study is planned as reports from other affected net-pen farms indicate that the anomaly may have several causes.

South Atlantic King Crab

In 1992, tissues from 145 South Atlantic king crabs (*Paralomis spinosissima*) were collected for disease studies. To date, 100 of the specimens have been examined. The skeletal muscle of two crabs were infected with an undescribed apansporoblastic microsporidan. Another nine crabs were parasitized by a rhizocephalan believed to be *Briarosaccus callosus*, but no cypris larvae were present to confirm this tentative identification. The most interesting of the encountered anomalies in South Atlantic king crabs was the hyperparasitism of three rhizocephalans by a parasitic isopod. The life history of these aberrant parasites is not well known, and identification is dependent upon examination of their larvae. Fortunately, larvae were found within the brood pouch of several females, and efforts are currently under way to properly describe their morphology. Nuclear and cytoplasmic polyhedral inclusions in the F- and R-cells of the hepatopancreas were found in all examined crabs. Several inclusions are typical within the cytoplasm of a single cell, while only one or two small inclusions are common within the nucleus of affected cells. The cause and identity of the inclusions has not been determined.

Steller Sea Lion Pup Hematology

A study on the morphology of red and white blood cells and the differential counts of white blood cells of Steller sea lion (*Eumetopias jubatus*) pups was completed in 1993. Blood was collected and smears were prepared from pups from five rookeries throughout the Gulf of Alaska in an effort to begin gathering baseline values. White and red blood cell counts varied between the sites, but all values fell within the normal range of values reported in the literature. However, the white blood cell data suggested the presence of a monocytosis and lymphopenia in sampled pups. The red blood cell data suggested a poikilocytosis and an increase in the presence of target cells. Both observations indicate that sampled pups were experiencing a physiological stress response, but more data and observations are required before the stressor can be identified.

RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION

The Resource Ecology and Fisheries Management (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 1992-93, the Observer Program at the AFSC was responsible for two separate programs: a domestic groundfish observer program and a high-seas driftnet fisheries observer program.

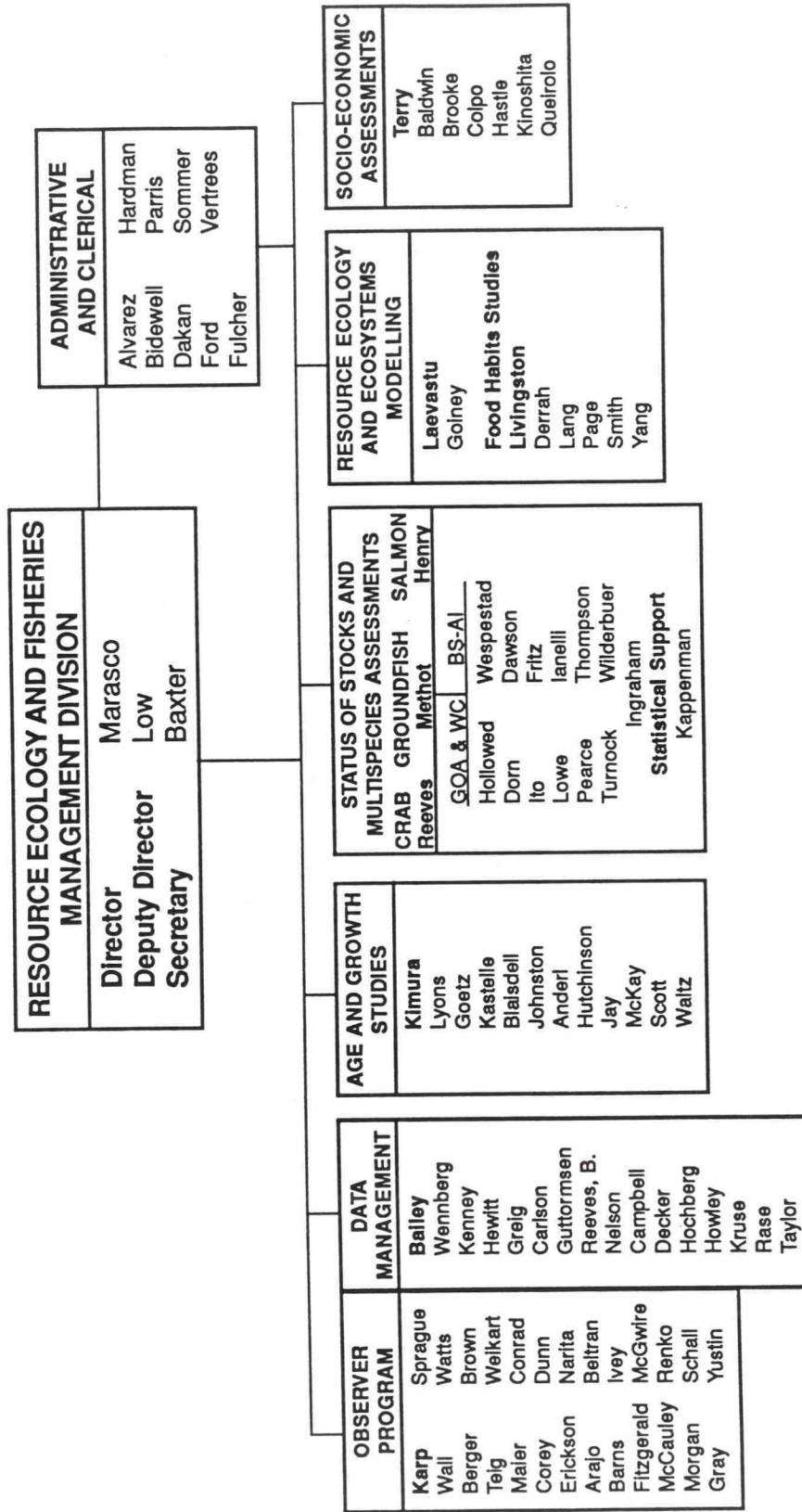
Domestic Groundfish Observer Program

Since 1990, Federal fisheries regulations have required mandatory observer coverage for domestic groundfish fisheries off Alaska. In 1992 and 1993, scientific observers continued to be placed on domestic vessels and at shoreside processing facilities to meet the mandatory observer coverage requirement. Some observers were also placed aboard volunteer 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 with fishing regulations.

During 1992 and 1993, the program deployed 1,204 observers on 397 different vessels and at 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

RESOURCE ECOLOGY AND FISHERIES MANAGEMENT DIVISION ORGANIZATION CHART 1992-93



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 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 recruiting and deploying observers; observer logistics, insurance, and employee benefits; and delivery of observer data to the NMFS.

Work continues on developing the North Pacific Fisheries Research Plan, which will change the current contracting arrangement. Groundfish, halibut, and crab vessels will be assessed a fee of up to 2% of the ex-vessel value of their harvest. The NMFS will then contract directly with private companies to provide observer coverage. This new system will also greatly reduce the possibilities for conflicts of interest between observer contractors and vessel owners.

High-Seas Driftnet Fisheries Observer Program

Japan, the Republic of Korea, and Taiwan conducted large-scale high-seas driftnet fishing in the North Pacific Ocean until 31 December 1992. During 1989 through 1991, the U.S. Driftnet Program participated in joint monitoring efforts with Canada, Japan, Korea, and Taiwan. Observers from each nation were deployed to driftnet vessels to record data on driftnet set and retrievals, catch and bycatch, and environmental conditions and to collect biological samples and specimens. The REFM Division became part of the U.S. Driftnet Monitoring Program in 1990, when it was given the responsibility of deploying scientific observers to high-seas driftnet vessels from Japan, the Republic of Korea, and Taiwan. The program also became responsible for editing and distribution of the data. This observer program required close cooperation between the REFM observer program, the ABL, NMML, the Honolulu Laboratory (Southwest Fisheries Science Center), and the U.S. Fish and Wildlife Service Region 8 (Anchorage).

During 1990-91, 108 U.S. observers monitored 4,841 driftnet operations on 124 cruises. Foreign observers from Canada, Japan, Korea, and Taiwan accounted for an additional 4,791 operations monitored.

In 1991, Japan, Korea, and Taiwan agreed to abide by United Nations General Assembly Resolution 46/215 calling for an end to all high-seas driftnetting by 31 December 1992. Because driftnetting was to end, no observers were deployed during 1992. The REFM Observer Program concentrated on fulfilling obligations for producing reports describing the observations of the 1991 fisheries and assisting the program's research portions to use the wealth of data collected under the monitoring agreements.

Observer reports describing each of the 1991 fisheries were produced in 1992 and early 1993. To complete this, REFM driftnet staff coordinated with and assisted the Korean and Taiwanese driftnet programs in data editing and quality assurance. The research portions of the U.S. Drift-net Program were involved in summarizing and analyzing driftnet data. The REFM driftnet staff provided technical support for these activities.

Due to the needs of the observer field program, only preliminary database development and management had been completed prior to 1993. During 1993, tasks were undertaken to finalize all aspects of the driftnet program. A contract was created for developing a relational database to incorporate the different data types, sources, and products. Final data quality control and archiving were nearly completed. Detailed catch-log time-interval data coding and quality control were undertaken, as well as steps to make the driftnet data more widely available and to ensure the long-term utility of these data.

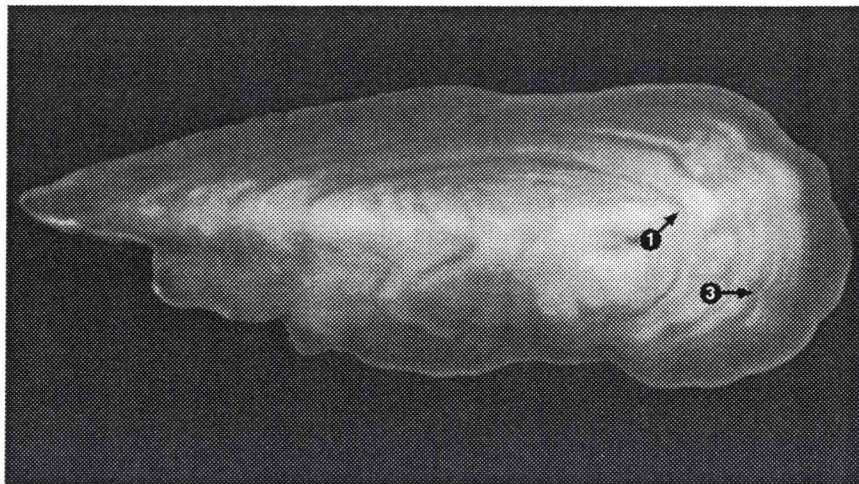
Contracted scientists participated in foreign research cruises operating in the North Pacific Ocean. Data obtained from the research cruises complemented the data obtained on commercial driftnet vessels. In 1993, REFM became responsible for deploying scientists to foreign cruises and administered the contracting, preparation, and coordination with foreign programs to deploy three U.S. scientists.

Age and Growth Studies

The primary responsibility of the Age and Growth Task is to determine the age of fish. This is achieved by counting the annual growth rings on otoliths, scales, and fin-rays. The Task also establishes ageing criteria for new species, examines problem areas where the generated ages appear unsatisfactory, and validates the ages being generated. Data from the Task are used to model fish populations dynamics. Currently the Task is ageing rock sole (*P. bilineatus*), rex sole (*Errex zachirus*), yellowfin sole (*Pleuronectes asper*), arrowtooth flounder (*Atheresthes stomias*), Kamchatka flounder (*A. evermanni*), walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), Atka mackerel (*Pleurogrammus monopterygius*), Pacific whiting (*Merluccius productus*), Pacific ocean perch (*Sebastes alutus*), northern rockfish (*Sebastes polyspinis*), and dusky rockfish (*Sebastes ciliatus*). Total ages read for 1992 and 1993 were as follows:

Year	Raw	Test	Age Category		Special	Totals
			Re-aged	Unageable		
1992	27,345	8,194	3,904	884	2,046	42,373
1993	17,085	4,959	2,598	265	5,370	30,277

Members of the Age and Growth Task count annual growth rings in fish otoliths to determine the ages of certain fish species. Data derived from the Task are used to model fish population dynamics. Pictured is an otolith of a 20-year-old sablefish with arrows indicating first and third yearly growth rings.



The Task has investigated various otolith preparation techniques with the objective of making the more difficult flatfish otoliths more readable. Various dyes and baking techniques were studied, but baking seemed to be more effective than dyes. In a major attempt to validate the ageing criteria, a radiometric facility was set up to age otoliths. To our knowledge, this is the only laboratory within NMFS that has radiometric ageing capabilities.

Status of Stocks and Multispecies Assessments

The primary role of the Status of Stocks Task is to assess the condition of groundfish resources in the northeast Pacific Ocean and to analyze strategies for management of those resources. In addition, the Task supplies technical support for fishery management and conducts research to improve the quality of the stock assessments.

Stock Assessment

In waters off Alaska, Task members continued annual assessments of walleye pollock, Pacific cod, yellowfin sole, Greenland turbot (*Reinhardtius hippoglossoides*), sablefish, Pacific ocean perch, other commercially important rockfish and flatfish, thornyheads (*Sebastolobus* spp.), and Atka mackerel. Off the West Coast, Task members assessed Pacific whiting, Dover sole (*Microstomus pacificus*), petrale sole (*Eopsetta jordani*), sablefish, and Pacific ocean perch. Expanded areas of investigation include use of new size-structured assessment models; quantification of risk associated with uncertainty in stock assessment forecasts (particularly for Pacific ocean perch and pollock in the Gulf of Alaska); and analysis of the impact of spatial patterns in the fishery.

Research

A comprehensive working plan to improve rockfish (*Sebastes* spp.) stock assessments and management recommendations was completed, and diverse projects were initiated. Task members analyzed the potential for rebuilding Pacific ocean perch stocks in the Gulf of Alaska, directed a study on rockfish growth and maturity in continental slope areas, and coordinated a pilot rockfish survey to determine the feasibility of employing commercial rockfish trawlers as survey platforms for assessing stocks of rockfish on the continental slope.

Task members served on nationwide NMFS committees to improve the quality of our stock assessment advice. Working groups on risk assessment and age-structured methods comparisons met during 1992-93. Two Task members also served on an international panel of fishery scientists for the purpose of evaluating definitions of "overfishing," currently employed by fishery management councils around the country.

A workshop to develop Bering Sea-wide walleye pollock assessment models was held in February 1992. Results indicated that plausible models could be constructed, but additional data from the western Bering Sea was needed to refine the models and estimates. In 1993, a Task member traveled to Russia to help develop these data and models.

The advent of PICES (North Pacific Marine Science Organization) has provided a new international forum for exploring ecosystem and climate effects on the potential yield of fish stocks in the North Pacific Ocean. Particularly relevant are the Task's internal and collaborative studies of variations in ocean conditions relative to the recruitment success of northeast Pacific Ocean groundfish and the Task's participation in a workshop on the ecology of juvenile walleye pollock. Task members are serving on three PICES working groups.

The fraction of the Pacific whiting stock that migrates northward into Canada each summer has been an issue in negotiations on the allocation of available yield between the United States and Canada. Relationships between the fraction of the whiting in Canadian waters during summer, sea temperature, and monthly long-shore surface currents were demonstrated by Task members and discussed at a U.S.-Canada Technical Working Group meeting on Pacific whiting.

An ultrasonic tag and tracking system to assess the viability of individual trawl-caught and released Pacific halibut (*Hippoglossus stenolepis*) is under development. The system consists of an acoustic tag attached to the fish, an array of moored sono-buoys for tracking tags, and a computer which integrates radio transmissions from the sono-buoys and provides real-time data on fish location and viability. REFM and Pentec Environmental (Edmonds, Washington) personnel continue to work closely with Seattle Aquarium staff on testing the viability (heart-rate) tag.

The OSCURS (Ocean Surface Current Simulations) numerical model is used to investigate oceanographic and atmospheric indices associated with changes in fish stocks. The model has been used to simulate trajectories of sockeye salmon (*Oncorhynchus nerka*) during the ocean migration phase of their return to the Fraser River, and similar studies of Pacific whiting migration are in progress. In a novel application, the model tracked 80,000 Nike sneakers spilled off a container vessel during a storm in May 1990. Strong agreement between the model track and actual recoveries of the shoes on the Washington-Vancouver Island coasts enhances calibration of the model and indicates that drifting shoes behave similarly to drift bottles and satellite-tracked drifting buoys.

Increasingly sophisticated computer technologies, including a Geographic Information System, are now available at the AFSC. With these tools, Task members can more efficiently and comprehensively analyze spatial data: patterns of bycatch in the fishery, distribution of fish around Steller sea lion rookeries, and potential abundance indices derived from fishery catch rates in local areas.

Fishery Management Support

Three Task members served on groundfish management teams for the North Pacific Fishery Management Council (NPFMC) and Pacific Fishery Management Council (PFMC). Task members have been involved in several analyses and reviews in response to the needs of the councils and NMFS Regional Offices. A risk assessment model was developed to analyze rebuilding policies for Pacific ocean perch in the Gulf of Alaska. A new size-structured assessment model was used to explore the implications of alternative Pacific cod allocations among gear types and seasons.

Potential biological impacts of pollock allocations were reviewed. Other Task members analyzed the impacts of splitting the Aleutian Islands into multiple management areas, particularly for Atka mackerel. The Task continues to analyze Bering Sea and Gulf of Alaska fishery data to discern Pacific halibut discard mortality. Task members provided detailed descriptions of the distribution of salmon bycatch in the Pacific whiting fishery off the West Coast and gave technical support for U.S.-Canada negotiations regarding allocation of the whiting harvest. Perhaps most importantly, members of the Task have worked closely with scientists from the NMML and from other agencies in exploring the possible role of groundfish fisheries in the decline of the Steller sea lion population; Task members have also provided management recommendations for the fisheries given the present status of declining pin-niped populations.

Resource Ecology and Ecosystems Modeling

Trophic Interactions Studies

The Trophic Interactions Program studies the food habits and trophic relations of key groundfish predators in the North Pacific Ocean. These groundfish predators consume commercially important prey and are targets for commercial fisheries. Quantifying food web linkages is essential to increase our understanding of how external forces such as fishing may cause unanticipated shifts in ecosystem composition. The importance of this research is also elevated given the increasing emphasis on fishery-marine mammal interactions; understanding groundfish predation interactions is an important part of knowing the true nature of resource availability to marine mammals and birds. Research emphasis is on interannual changes in groundfish predation on commercially important prey and comparisons with removals by marine mammals, birds, and fisheries. Quantification of predation mortality of juvenile fish and incorporation of these estimates into population assessment models is beginning and will become a major focus of the Trophics Interactions Program.

The Trophic Interactions Program continued regular monthly observer training for collection of food habits information on key groundfish species in the North Pacific Ocean. In addition, program personnel collected fish stomach samples during resource assessment surveys in the eastern Bering Sea, Gulf of Alaska, and off the Washington-Oregon-California coasts. The following numbers of fish stomachs were collected, scanned at sea, and analyzed in the laboratory in 1992 and 1993:

Year	Collected	Scanned	Analyzed
1992	9,842	361	14,272
1993	18,032	536	15,566

Research conducted in 1992-93 included: summarization of Bering Sea groundfish diet and consumption of commercially important prey for 1987-89; comparison of groundfish removals of walleye pollock and Pacific herring (*Clupea pallasii*) relative to removals by marine mammals and birds in the eastern Bering Sea; completion of diet comparisons between small-mouthed flatfish in the Bering Sea; parameterization and sensitivity analysis of a bioenergetics model for walleye pollock; summarization of Gulf of Alaska groundfish food habits in 1990; consumption of pollock, herring, and capelin (*Mallotus villosus*) by groundfish and pinnipeds in the Gulf of Alaska; interdecadal comparison of pollock food habits in the Bering Sea; and incorporation of predators (pollock, cod, and fur seals) into the synthesis population assessment model of Bering Sea pollock.

Socioeconomic Assessments

The Socioeconomic Task provided economic information and assistance to the PFMC and NPFMC, industry, the 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. The Task was instrumental in implementing a coordinated data collection program for the domestic fisheries off Alaska.

Task members contributed to the development of studies to evaluate the 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.

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 the 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. The NMFS funded projects on modeling dynamic fish populations and price models for king crab (*Paralithodes* spp.).

Technical Liaison

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



AWARDS AND HONORS

Grant Thompson (REFM) received a NOAA Certificate of Recognition for his efforts in reviewing and responding to Endangered Species Act Petitions for anadromous salmonids.

Russell Nelson (RACE) received a NOAA Administrator's Award for management of the AFSC's Observer Program from 1982 through 1992.

Russell Nelson (RACE) was presented with the Jerry Jurkovich Award for 1993.

James Coe (CD), Michael Dahlberg (ABL), Shannon Fitzgerald (REFM), Steven Ignell (ABL), and Linda Jones (NMML), received a Department of Commerce Silver Medal Award for initiating and carrying out scientific investigations on the impacts of foreign driftnet fishing on the Nation's living marine resources.

Dan Twohig (RACE) received a Bronze Medal Award for his work in developing the AFSC's quantitative fisheries stock assessment capabilities.

Chris Wilson (RACE) and David Somerton (RACE) received a Bronze Medal Award for the invention of hook timers that measure individual fish capture times and their application to fisheries stock assessment.

Thomas Loughlin (NMML) and Richard Merrick (NMML) received a Department of Commerce Silver Medal Award in recognition of their dedication to scientific excellence in the comprehensive research of the Steller sea lion resulting in the protection and conservation of the Steller sea lion and its habitat.

Lewis Queirolo (REFM) was awarded a Department of Commerce, NOAA Certificate of Recognition from Under Secretary Knauss, "For Outstanding Contributions as a NOAA Employee Servicing the Public Trust in Response to the Exxon Valdez Oil Spill Disaster in April 1989" and "As a Member of Alaska Region Office of Oil Spill Damage Assessment and Restoration."

Lewis Queirolo (REFM) and Joseph Terry (REFM) were coauthors of a publication awarded recognition in 1992 for the best publication of 1990 appearing in *Marine Fisheries Review*. The paper's title is, "U.S. Fisheries Management and Foreign Linkages: Policy Implications for Groundfish Fisheries in the North Pacific EEZ."

Vidar Wespestad (REFM) received a Distinguished Service Award from the American Fisheries Society.

ADVANCED DEGREES

Nazila Merati (RACE) received a Masters Degree from the University of Washington.

Michael Sigler (ABL) received a Ph.D. in Fisheries from the University of Washington, School of Fisheries.

Frank Morado (RACE) received a Ph.D. in Fisheries from the University of Washington, School of Fisheries.

James N. Ianelli (REFM) received a Ph.D. from the University of Washington.

Geoffrey M. Lang (REFM) received a Masters Degree from the University of Washington, School of Fisheries.

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