

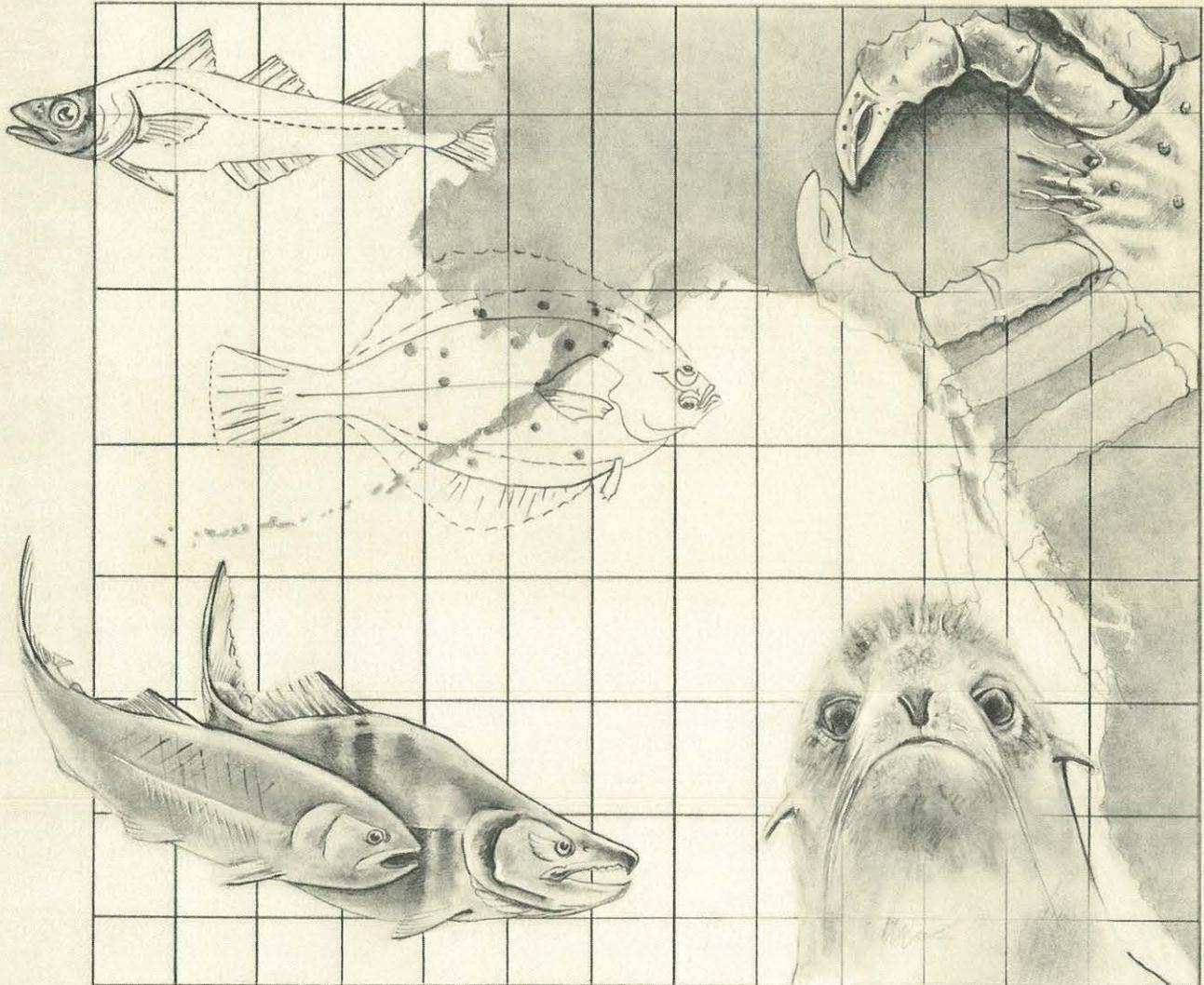


**Northwest and
Alaska Fisheries
Science Centers**

**National Marine
Fisheries Service**

U.S. DEPARTMENT OF COMMERCE

Annual Report for Calendar Year 1988



Annual Report

Northwest and Alaska Fisheries Science Centers Seattle, Washington

CALENDAR YEAR 1988

Compiled by

**Publications Unit
Northwest and Alaska Fisheries Science Centers
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Cover by Kathi Zecca, AFSC

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Science Centers, Seattle, Washington)**

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INTRODUCTION

In 1988 the Northwest and Alaska Fisheries Center was divided into the Northwest Fisheries Science Center and the Alaska Fisheries Science Center, which conduct research and provide technical information to the National Marine Fisheries Service (NMFS) Northwest Regional Office and the Alaska Regional Office, respectively. In the 1988 the Auke Bay Laboratory (ABL), the National Marine Mammal Laboratory (NMML), the Resource Assessment and Conservation Engineering (RACE) Division, the Resource Ecology and Fisheries Management (REFM) Division, and the Office of Fisheries Information Systems (OFIS) were brought together to form the Alaska Fisheries Science Center. The Northwest Fisheries Science Center is made up of the Coastal Zone and Estuarine Studies (CZES), Environmental Conservation (EC), and Utilization Research (UR) Divisions. The restructuring recognized the need for continued interaction between the two Centers. The RACE, REFM, and UR Divisions and the NMML have program responsibilities which apply to both the Northwest and Alaska regions. The ABL and the CZES Division, which have considerable salmonid expertise, continue to coordinate parallel activities regarding U.S.-Canada salmon treaty work, and the EC Division and ABL have critical roles in environmental sciences.

The scope of research responsibilities of the two Centers extends from rivers and coastal waters of California, Oregon, Washington, and Alaska to the western Pacific Ocean, an expanse of more than 2,900,000 square miles. Passage of the Magnuson Fishery Conservation and Management Act and establishment of the 200-mile fishery conservation zone in 1976 (changed to Exclusive Economic Zone (EEZ) by Presidential Proclamation in 1983) gave new impetus to the Centers to conduct research in support of conservation and management of fishery resources of this region. Scientists at the Centers study the life history of this region's aquatic species and examine ways to enhance their production and utilization. They estimate the size and value of commercial fishery resources, monitor foreign fishing operations, provide information on protected species, and study the physical properties of freshwater, estuarine, and marine environments and the effects of physical alteration and chemical contaminants on aquatic biology. Scientists also interact with their counterparts in Canada, Japan, the U.S.S.R., Republic of Korea, Taiwan, and other nations to jointly preserve and conserve the area's resources.

Table 1 gives names of permanent employees of the Centers who left during 1988 as a result of retirement.

Table 1.—Full-time permanent individuals who retired from the Northwest and Alaska Fisheries Science Centers during calendar year 1988.

Name	Division/ Laboratory	Termination date	Length of service	
			Years	Months
Warren Ames	EC	01/01	30	11
Patricia J. Arasmith	ABL	01/01	22	09
Wesley J. Ebel	CZES	06/03	33	05
Alice S. Hall*	UR	01/02	26	07
Anthony J. Novotny	CZES	01/02	31	02
Howard L. Raymond	CZES	01/02	30	02
Carl W. Sims	CZES	01/02	31	02
John Spinelli	UR	04/01	25	07
Fred M. Utter	CZES	01/30	31	07
Beverly M. Vinter	RACE	07/29	16	11

*Since deceased.

ABL = Auke Bay Laboratory; CZES = Coastal Zone and Estuarine Studies Division; EC = Environmental Conservation Division; RACE = Resource Assessment and Conservation Engineering Division; UR = Utilization Research Division.

ORGANIZATION CHART - 1988

NORTHWEST CENTER DIRECTOR'S OFFICE

Center Director
Richard J. Berry

Secretary
Susan M. Rose

Deputy Center Director
Warren K. Taguchi

ALASKA CENTER DIRECTOR'S OFFICE

Center Director
William Aron

Secretary
Patricia Kerlik

Deputy Center Director
B. F. Jones

Secretary
M. Taka Kogita

Senior Policy Advisor
O. E. (Bud) Kerns, Jr.

Scientific Consultant
M. E. Stansby

Office Services Unit
John Richards
Presalynn Black
Shawn Humrich

Building Maintenance Unit
Delbert Hollum, Chief
Jim Andrews
Steve Powell
Barry McDonald
Bill Snyder

Entanglement Research
James Coe, Manager
Alan Bunn

Office of Fisheries Information Systems*
Ted Rodgers, Director

Montlake Library
Pat Cook, Librarian

Plans & Program Evaluation
Norris Jeffrey

Administrative Services
Alyce Wilson, Budget Analyst
Barbara Prater, Adm. Assistant
Janet Holbrook, Adm. Clerk

Publications Unit
Gary Duker, Chief
Sharon Giese
Susan Calderon
Jean Davis
Nancy Pagh
Kara Amundson**

Graphics Unit
Jim Peacock, Montlake
Karen Conlan, Sand Point
Wendy Carlson
Kathi Zecca

*See separate Organization Chart for OFIS, page 30

**Replaced Pagh Aug. 29, 1988

NORTHWEST FISHERIES SCIENCE CENTER

The Northwest Fisheries Science Center's programs are carried out at the Montlake Laboratory in Seattle and at biological field stations in Cook, Manchester, Mukilteo, and Pasco, Washington; Point Adams and Bonneville, Oregon, and Kodiak, Alaska. Various NOAA research vessels are used for coastwide sea sampling, while more localized studies employ the Center's *Harold W. Streeter*, *Sea Otter*, or smaller boats.

The Montlake Laboratory, located on the shore of Lake Union and adjacent to the University of Washington campus, has been a focal point for fisheries research for over 55 years. It features modern chemistry, physiology, microbiology, and genetics laboratories as well as extensive equipment for testing innovative fish processing technology. The Laboratory also has new hatchery facilities capable of holding 300,000 salmonid smolts and supports small on-site runs of salmon and steelhead.

The Center's Manchester Marine Experimental Station on Puget Sound has seawater laboratories and an extensive net-pen system for rearing salmonids from smolts to adults. The Mukilteo field station, also on Puget Sound, features holding tanks and bioassay facilities for assessing the effects of contaminants on marine organisms. Studies conducted from the Cook, Pasco, and Bonneville stations are directed toward enhancing the survival of salmon migrating past dams in the Columbia River system and improving the quality of smolts released from hatcheries. The Point Adams site houses the research base for environmental studies in the Columbia River estuary. And, in Alaska, the Kodiak station supports research to assist the fishing industry in more fully and economically utilizing their harvests.

COASTAL ZONE AND ESTUARINE STUDIES (CZES) DIVISION

The CZES Division has field facilities at Bonneville, Cook, Manchester, and Pasco, Washington, and at Hammond, Oregon. Research activities are divided into three Tasks: Fisheries Enhancement, Ecological Effects of Dams, and Habitat Investigations.

Fisheries Enhancement

Chinook Salmon Brood-Stock Program

This program is directed at maintaining seriously threatened or depleted stocks of salmonids in captivity throughout their entire life span. Husbandry studies in 1988 continued focussing on diagnosis, treatment, and prevention of infectious and nutritional diseases in marine cultured salmon. About 1,500 spring chinook salmon from the White River (Washington) are maintained at the Manchester Marine Experimental Station as part of a cooperative program of the NMFS and the Washington Department of Fisheries (WDF). These salmon are the last remaining group of spring chinook salmon native to Puget Sound; the NMFS experimental brood-stock program provides 30 to 50% of the eggs available for their enhancement.

Endocrinology of Smoltification

The smoltification of juvenile salmon involves morphological, physiological, and behavioral adaptations for downstream migration and residence in the ocean. The endocrine system plays a pivotal role in controlling the rate and completeness of smoltification. Changes in the levels of hormones can be used as indicators of the timing, duration, and strength of smoltification. Several hormones show distinct patterns of change either immediately before or during smoltification. Blood levels of insulin show a distinct peak at the beginning of the transformation. Increased activity of the thyroid gland during smoltification is associated with increases in blood plasma concentration of thyroxine (T4) and, depending on the salmonid species, triiodothyronine (T3). Plasma cortisol and other growth hormones involved in seawater adaptation begin to increase when levels of T4 are near their peak. Plasma levels of epinephrine and norepinephrine become elevated near the end of smolt development and remain high during desmoltification of fish retained in fresh water. Measured changes in these hormones can be used in combination with other smolt indicators (e.g., gill Na⁺-K⁺ ATPase) to indicate the appropriate time for hatchery release of smolts or for transfer

of fish from fresh water to seawater. These indicators may also be useful for determining the effectiveness of hatchery rearing techniques and fish guidance systems at hydroelectric dams.

Salmon Reproduction

The Task is studying the endocrine control of the reproductive cycle of Pacific salmon. Reproduction in salmon is influenced by environmental variables (e.g., the seasonal changes in day length (photoperiod) and water temperature). Photoperiod information processed by the brain controls the pituitary gland which releases gonadotrophic hormones to stimulate development of the testes in the male and ovaries in the female. It was thought that the pituitary gland contained only one gonadotropin (GTH). Recently, however, it was discovered that there are two GTHs--GTH1, in the pituitary glands of both juvenile and adult salmon, and GTH2, found only in the glands of adults. CZES scientists are comparing the relative biological activities of GTH1 and GTH2. Our hypothesis is that GTH1 may play an important role in early reproductive events, such as multiplication of spermatogonia and oogonia, whereas both hormones may be involved in spermatogenesis and ovulation (spawning). These studies may provide insight into the mechanisms responsible for precocious maturation of male salmon (jacks) and the determination of the numbers of eggs produced in females (fecundity).

New Rearing and Release Strategies for Columbia River Hatcheries

Tagged subyearling spring chinook salmon from an accelerated rearing program were released in May and June of 1983, 1984, and 1985 from the Little White Salmon Hatchery near Cook, Washington. For survival comparisons, tagged yearling fish were also released in April (normal release strategy) 1984 and 1985. Most of the adults have now returned, and preliminary information indicated a survival ratio of 3-4:1 for yearlings over subyearlings released the same year. However, since three or four times as many subyearlings than yearlings can be reared in the same facilities in about 10 or 11 months less time, the rearing and release of accelerated subyearling spring chinook salmon appears to be a cost effective strategy for the Little White Salmon Hatchery.

PIT-Tagging System

A cooperative program between CZES and BPA to evaluate the technical and biological feasibility of the PIT tag for salmonid research has been under way since 1983. When inserted into the body cavity, this 12-mm long by 2-mm diameter electronic tag can mark individual fish with one of 34 billion unique codes. The tag can be automatically detected and decoded in situ, eliminating the need to anesthetize or handle fish

during data retrieval. Tag monitoring equipment has been installed and tested at several sites in the Columbia River Basin (i.e., there are detectors at juvenile fish collection facilities at Lower Granite, Little Goose, and McNary Dams and at the adult fish collection facility at Lower Granite Dam).

Efforts during 1988 focused on extending the detection range of the tag and developing an automated system to collect or divert PIT-tagged fish at Lower Granite Dam. In addition, a cooperative study with WDF to document the effects of the PIT tag in coho salmon was begun at the Skagit River Hatchery near Marblemount, Washington and an automated PIT-tag database was developed in cooperation with the Pacific Marine Fisheries Commission.

Experiments are being planned to test the effects of the PIT-tag monitoring system on volitional movement of juveniles and adults through PIT-tag monitors.

Yakima River Basin Sockeye Salmon Restoration Program

CZES is a partner with BPA in a study to determine the feasibility of restoring anadromous sockeye salmon to Cle Elum Lake in the Yakima River Basin. This program involves the collection of donor stock adult sockeye salmon from the Wenatchee River Basin (1987 through 1991) for brood supply. The goal of the adult collection program is to provide disease-free juvenile sockeye salmon for enhancement studies.

A major concern is the infectious hematopoietic necrosis (IHN) virus which is a particular problem in sockeye salmon. During 1988, 520 adults were captured, held to maturity in net-pens in Lake Wenatchee, and their gametes were moved to a quarantine rearing facility at the NMFS Montlake Laboratory in Seattle. Prespawning survival was over 85%, and all spawners (in both 1987 and 1988) were IHN-free, while natural river spawners had a prevalence of nearly 90%. Our results suggest that IHN infection can be minimized if adults are allowed to mature away from the spawning grounds.

Over 100,000 1987-brood juveniles were freeze-branded and coded-wire-tagged. Smolts from these marked fish are being raised and will be released for outmigration studies in Cle Elum Lake and the Yakima River during 1989. A temporary fish-holding facility was constructed at Cle Elum Dam, and PIT-tag detectors were installed at the fish collection facility at Prosser, Washington, on the Lower Yakima River. Almost 105,000 fry from the 1988 spawning are being reared at the Montlake Laboratory, and juveniles will be used for outmigration studies in 1990.

Mid-Columbia Spring Chinook Salmon Seawater Survival Tests

During summer 1988, the Task began a cooperative study with the Grant County Public Utility District to determine the survival of subyearling (zero-age) spring chinook salmon smolts following seawater entry. Three groups of accelerated subyearling and one group of yearling spring chinook salmon smolts from the Leavenworth National Fish Hatchery near Leavenworth, Washington, were transferred to seawater net-pens at the Manchester Marine Experimental Station. Growth and survival were documented for approximately 120 days of seawater culture. Growth was good in all treatments, with no losses directly attributed to osmoregulatory dysfunction. However, mortality from bacterial kidney disease in the yearling fish was more than double that in the three groups of subyearling spring chinook salmon. Results of this trial suggest that the degree of infection and hence mortality from bacterial kidney disease in seawater may be related to age and the length of time spent in the freshwater hatchery.

Grays Harbor Coho Salmon Survival Study

Returns of adult coho salmon to the Chehalis River in southwest Washington are traditionally much poorer than returns to the nearby Humptulips River. These differences in survival prompted investigations by CZES and other federal and state biologists into the status of health and smoltification of wild and hatchery coho salmon produced in each river system. In 1988, coho salmon smolts from the Humptulips Hatchery were exposed to either Chehalis or Humptulips estuary water and then transferred to seawater at the NMFS Manchester Marine Experimental Station. While in marine net-pens, the coho salmon received a natural challenge of vibriosis, a marine bacterial disease. Mortality was significantly higher in fish exposed to Chehalis estuary water, suggesting that Chehalis estuary water may compromise immune competence in the smolts. Environmental physiology studies will determine possible physical or chemical reasons for the poor survival.

Genetic Stock Identification of Pacific Salmon (U.S.-Canada Salmon Treaty)

Much of the genetic research in CZES is based on the technique of protein gel electrophoresis to detect genetically-based protein variation. Stocks of salmon differ in the frequencies of protein variants. The primary goal is to describe the amount and pattern of protein differentiation among stocks in a baseline dataset and to apply this information to problems of stock mixtures in fisheries. This technique is being used on a coastwide basis to monitor specific chinook salmon stocks in fisheries of interest to U.S.-Canada Treaty managers.

In 1988, the genetic baseline for chinook salmon was expanded in the Fraser River System to include six new locations in northern British Columbia and in southeastern Alaska for several major hatcheries. In addition, an effort was made to develop systems to automate the transfer of homogenized protein samples to gels, capture data from gels using high resolution image capture and data processing equipment, and enter data directly from the gels to microcomputers.

Ecological Effects of Dams

This Task conducts applied research relating to migrations of anadromous salmonids (*Oncorhynchus* spp.) in the Columbia River Basin. Studies are conducted on the effects of dams on river environment and passage and survival of fish. Emphasis is placed on development and evaluation of systems to enhance safe juvenile and adult passage.

Research is conducted at hydroelectric projects on the Snake and Columbia Rivers. Nearly all studies are cooperative efforts involving the U.S. Army Corps of Engineers (COE), Bonneville Power Administration (BPA), or public utilities of the Columbia River Basin.

Fish Guiding Efficiency Studies at Bonneville Dam

To protect juvenile salmonids migrating downstream past hydroelectric dams, the fish are diverted from turbine intakes into specially constructed bypass channels. The number of juveniles guided around turbines relates directly to overall fish survival. Fish guiding efficiency (FGE) tests were conducted during spring and summer 1988 in cooperation with the COE. Spring and summer studies at the second powerhouse tested turbine intake extensions, bar screens, and various illumination patterns to enhance guidance of downstream-migrating yearling chinook salmon.

Results indicated that turbine intake extensions significantly increased FGE; however, bar screens did not guide fish as well as conventional submerged traveling screens. Tests of lighting arrangements were inconclusive.

Relationship between Smolt Development and FGE at Bonneville Dam

Cooperative studies with the COE showed that advanced and well-smolted yearling spring chinook salmon (*O. tshawytscha*) in the Snake River resided high in the water column and therefore were susceptible to guidance screens that divert the shallower migrating juveniles from turbine intakes. Smoltification may be manipulated in

hatchery fish so that they might benefit from improved guidance when the fish arrive at the dams equipped with screens.

At Bonneville Dam, smoltification was measured for guided fish as well as for fish at various depths below operating fish screens. However, there was no significant correlation between smoltification status and FGE or guidance device effectiveness at either of the two Bonneville Dam powerhouses for yearling chinook, subyearling chinook, or coho (*O. kisutch*) salmon. Changing test conditions and restricted sampling procedures hampered interpretation of the data.

Advanced Photoperiod Treatment for Increasing Smoltification

At hatcheries, juvenile salmon that smolt earlier than those presently produced can take advantage of normal spring freshets to speed their travel time to downstream collection points at dams and to the ocean. Generally, the less travel time in the river, the higher the survival and the greater the adult return. During winter 1988, juvenile spring chinook salmon were exposed to a 14-week advanced photoperiod at Dworshak National Fish Hatchery. Treated fish were released about 1 April with normal hatchery production.

Marked fish from the test groups were recovered at Lower Granite Dam and other points on their seaward migration. Fish with photoperiod treatment traveled to Lower Granite Dam significantly faster than their nontreated counterparts (21 days vs. 28 days), and more treated than nontreated fish were recovered. A detailed study is planned for 1989 based on 1988's encouraging results.

Collection Efficiency Studies at McNary Dam

Collection efficiency at a dam is measured by the number of smolts in the collection system vs. those passing the dam through all alternate routes. This observation is vital if fishery managers are to determine populations of smolts arriving at specific dams. McNary Dam is an important collection dam and precise population estimates are desired. During spring 1988, efforts were made to evaluate collection efficiency for populations of spring chinook and sockeye (*O. nerka*) salmon and steelhead trout (*O. mykiss*, formerly *Salmo gairdneri*) at McNary Dam. However, 1988 was an extreme drought year and no water was spilled at McNary Dam. Spill normally occurs and was to be an integral part of the experimental design. Therefore, additional tests are planned for 1989.

Smolt Transportation Studies at Lower Granite and McNary Dams

Transportation by barge and truck around selected dams currently protects juvenile salmonids at several dams on the Snake and Columbia Rivers. Recent modifications of fish collection systems at Lower Granite and McNary Dams require ongoing evaluation to determine if past benefits have been realized or improved. At Lower Granite and McNary Dams, smolts were marked with coded wire tags and released to the river (control) or transported by barge (test) to safe release sites below Bonneville Dam. The study indicated that more transported juveniles (spring chinook salmon and steelhead) are returning as adults than their nontransported counterparts.

In a new study, juveniles were marked with passive integrated transponder (PIT) tags in wild and natural production areas of Idaho and Oregon. Plans are to recover these fish next spring at Lower Granite Dam where, because of the PIT tags, they can be automatically assigned to test and control groups to further evaluate potential benefits of the transportation concept.

Habitat Investigations

The focus of research in the Habitat Investigations Task is to provide information for the protection, development, and balanced growth of the living aquatic resources in the lower Columbia River, the Columbia River estuary, and the adjacent nearshore ocean. This is accomplished with field and laboratory studies emphasizing the ecological effects of natural and human-induced changes on commercially and recreationally important marine and anadromous species and their supporting habitats. These studies assess the impacts of dredging and dredge disposal on the abundance, distribution, and size-class structure of benthic invertebrate and demersal fish communities and the ecological impacts of lower Columbia River hydroelectric development on physical, chemical, and biological processes in the estuary.

Habitat and Resource Surveys

During 1988, a survey of benthic invertebrates in the Umpqua River estuary (Winchester Bay, Oregon) at and adjacent to an interim, in-water, dredged-material disposal site was completed in cooperation with the COE. Analysis of sediment samples collected before and after disposal of dredged material indicated few changes in the overall abundance and species composition of the benthic invertebrate community at this site.

Research continued to document the abundance, distribution, and size-class structure of Dungeness crabs (*Cancer magister*) in the Columbia River estuary at and near frequently dredged areas. The Columbia River estuary is an important nursery area for this species and knowledge of the crabs' temporal and spatial distribution is critical in scheduling maintenance dredging activities to minimize adverse impacts.

During 1988, CZES initiated research with the COE to develop a long-term plan for the disposal of dredged sediment in the Columbia River estuary. The focus of this research is characterization of benthic invertebrate and demersal fish communities in the intertidal and subtidal areas adjacent to artificial islands previously created in the Columbia River estuary by the disposal of dredged material. These data will be compared to data collected over 15 years ago to assess the value of these islands as productive aquatic habitats.

West Coast Estuarine Inventory

Staff at the Point Adams Biological Field Station are continuing to work with National Ocean Service's Ocean Assessments Division compiling a summary database on living marine resources of major west coast estuaries. This information will be incorporated in NOAA's National Estuary Inventory. The goal of this project is to produce an atlas bringing together data on the distribution, abundance, and life histories of over 40 commercially, recreationally, and ecologically important species. Twenty-two estuaries have been identified for study. The completed atlas will be a valuable reference for environmental managers overseeing the development of these estuaries.

Columbia River White Sturgeon

The rapidly expanding recreational fishery for white sturgeon (*Acipenser transmontanus*) in the Columbia River estuary has occurred in the absence of adequate information on the abundance, distribution, reproductive biology, and habitat requirements of this species. In response to this critical need, CZES personnel are participating in a BPA-funded, multiagency research project to investigate the status and habitat requirements of white sturgeon. During the second year of this 5-year study, Task biologists conducted a comprehensive sampling program for eggs and larvae of white sturgeon from Bonneville Dam to the Columbia River estuary. This research will identify habitat requirements for spawning and rearing white sturgeon and quantify the extent of habitat available in the study area. During 1988, over 1,300 eggs and more than 2,600 juvenile white sturgeon were collected.

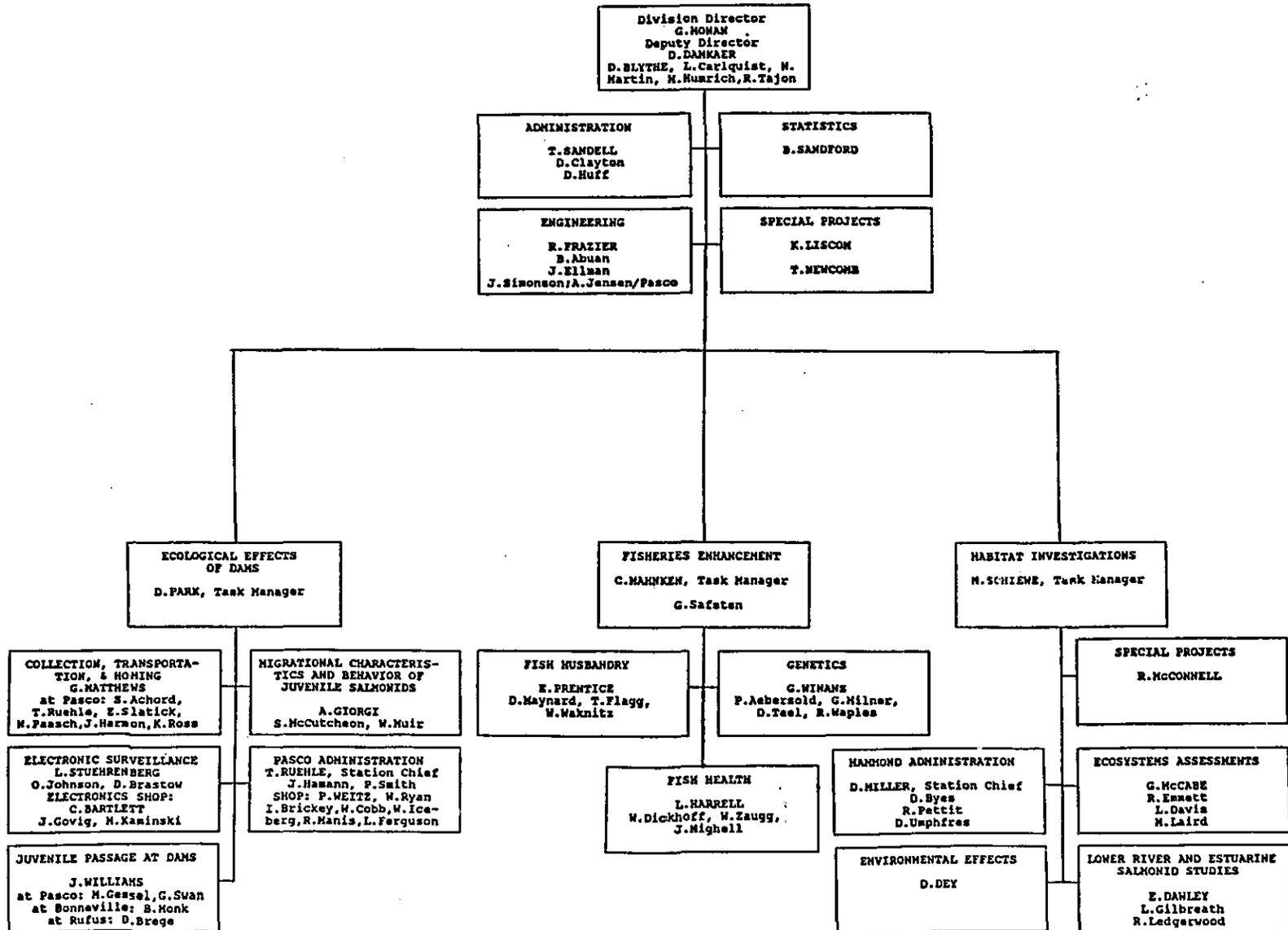
Juvenile Salmon Survival Studies

Research at the Columbia River's Bonneville Dam second powerhouse has shown that subyearling chinook salmon migrating in summer are not effectively guided into the bypass system from turbines equipped with submersible traveling screens. This has resulted in limited operation of the second powerhouse turbines and has raised several questions regarding juvenile fish passage at this hydroelectric dam. In 1987, NMFS, in cooperation with the COE, began a 3-year study to evaluate passage survival of juvenile chinook salmon passing downstream via the turbines, fish bypass system, and spillway.

In the second year of this project, about 2 million subyearling fall chinook salmon were marked with coded wire tags and cold brands and released at selected locations at and below the dam. The release locations were at the upper and lower turbine entrances, the entrance to the fish bypass system, the turbine frontroll boil, and downstream in mid-river. Because of low river flows in 1988, as in 1987, no spillway releases were made. Although information on long-term survival of the marked groups must await adult returns (i.e., recoveries in the commercial, recreational, and tribal fisheries and returns to the hatchery), data on short-term relative survival are being collected based on juvenile recoveries in the Columbia River estuary.

In 1988, as in 1987, recoveries of marked subyearling chinook salmon in the estuary indicated significantly decreased survival of fish released in the second powerhouse bypass system compared to other routes. Also of note was the reduced survival of all groups passing through the dam's tailrace area, which contains a large population of squawfish (*Ptychocheilus oregonensis*). Based on these early results, efforts are under way to identify and resolve problems with the fish bypass system at Bonneville Dam.

COASTAL ZONE AND ESTUARINE STUDIES DIVISION



ENVIRONMENTAL CONSERVATION (EC) DIVISION

Research Activities

Research conducted by the EC Division during 1988 encompassed both field and laboratory investigations designed to evaluate the nature and extent of pollution and its effects on marine species and their habitats. Highlights of this research included conclusion of a field and laboratory research project on the status of pollution on the west coast; continuation of field surveys on the west, gulf, and east coasts to assess the extent of chemical contamination of sediments and marine fish and the prevalence of diseases in marine fish; completion of the initial phase of a project showing reproductive impairment of English sole (*Parophrys vetulus*) due to environmental chemical exposure in Puget Sound; initiation of a multiyear project to evaluate reproductive processes in winter flounder (*Pseudopleuronectes americanus*) in Boston Harbor, Massachusetts; testing and refinement of biochemical techniques (such as radioactive phosphate postlabeling of DNA and aryl hydrocarbon hydroxylase activity) for use as indicators of contaminant exposure in a variety of marine fish species; implementation of cost-saving procedures for the chemical analysis of environmental contaminants; studies of butyltin contamination of fish tissues and bottom sediments in Puget Sound; and development of new bioassay methods for assessing the sublethal effects of chemically contaminated sediments.

National Benthic Surveillance Project

The Division completed Part I of a summary report on the status of chemical contamination on the west coast. This report covers the first 3 years (1984-86) of the National Benthic Surveillance Project (NBSP). The NBSP is part of NOAA's National Status and Trends Program (NS&T) and it assesses and documents the status and long-term changes in environmental quality of the Nation's coastal and estuarine waters. Results indicated the presence of high concentrations of polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons (CHs), and several metals (e.g., copper and lead) in sediments from many of the sites in major urban areas of California and Washington (e.g., San Diego Bay; San Pedro Bay, Long Beach/Los Angeles; and Elliott Bay, Seattle). In addition, relatively high concentrations of CHs were present in the livers of bottomfish collected at these same sites. The highest concentrations of fluorescent aromatic compounds (FACs), which reflect exposure to PAHs, in the bile of bottomfish were also found at these urban sites. Fin erosion and a variety of liver

lesions were also detected in some of the fish species examined, with the highest prevalences generally being found in fish from urban sites.

Division scientists also played an important and expanded role in the fifth year of NBSP sampling and conducted other NBSP-related field surveys. Because of the implementation of more efficient procedures for chemical analyses, the Division was able to conduct chemical analyses for fish and sediment samples collected for all NBSP sites on the west and gulf coasts and on the northern portion of the east coast. Chemical analyses of fish tissues and sediment samples and histopathological examinations of fish livers were completed for specimens collected during the fourth year (1987) of the project. The results of analyses of samples collected from four sites in Long Island Sound during 1987 indicated that the sampling site near New Haven, Connecticut, was the most affected in terms of both chemical contamination and biological effects (e.g., liver lesions) in winter flounder. The nonurban site at Niantic Bay had the lowest levels of chemical contamination in sediment and in fish and invertebrate tissues and generally the lowest prevalences of liver lesions in winter flounder. None of the sites sampled in Long Island Sound had contaminant levels or prevalences of lesions approaching the worst conditions previously found at other East Coast locations (e.g., Boston Harbor, Massachusetts; Raritan Bay, New York).

Biochemical Effects of Contaminants

The Division refined the use of the state-of-the-art method known as radioactive phosphate postlabeling for assessing chemical modification of DNA in marine fish exposed to complex mixtures of contaminants. The results of a field study showed that English sole from chemically contaminated areas in Puget Sound, Washington, and winter flounder from Boston Harbor, Massachusetts, had liver DNA with high levels of a variety of adducts, indicating exposure to several genotoxic compounds. Individuals of these species from relatively uncontaminated sites had DNA with low levels of adducts. Additionally, the major adducts detected had properties similar to the adducts of known carcinogenic PAHs. In a related study with the genotoxic PAH, benzo[a]pyrene, the level of benzo[a]pyrene-DNA-adducts in livers showed no significant change for up to 2 months after exposure. This result suggests that measurement of DNA adducts in wild fish populations may also provide valuable information on cumulative exposure to genotoxic compounds. Overall, the results of these studies indicate that the postlabeling assay for measuring DNA damage will be useful in environmental monitoring studies for assessing the extent of exposure of marine fish species to complex mixtures of genotoxic contaminants.

To further enhance the assessment of contaminant exposure in fish, the EC staff included aryl hydrocarbon hydroxylase (AHH) assay in the 1988 field surveys. Earlier

studies in the Division had shown that the level of this enzyme was a sensitive biomarker of exposure of fish to contaminants, such as PAHs and polychlorinated biphenyls (PCBs). Preliminary results from the NBSP show that the activities of liver AHH in different species of fish, such as white croaker (*Genyonemus lineatus*) from Southern California and flathead sole (*Hippoglossoides elassodon*) from Alaska, are reflective of the level of chemical contamination in the sediment where these fish were caught. The general utility of liver AHH as an indicator of exposure to diverse groups of chemical contaminants was also demonstrated by the induction of AHH in coho salmon (*Oncorhynchus kisutch*) exposed to a pulp mill effluent in laboratory bioassays.

An intensive year-long study in Puget Sound was initiated to evaluate the relative sensitivities of a suite of biochemical and biological indicators of contaminant exposure and early biological effects in benthic fish, as well as to determine if an indicator is species dependent. Three species of flatfish (English sole; starry flounder, *Platichthys stellatus*; and rock sole, *Lepidopsetta bilineata*) were sampled from various sites in Puget Sound chosen to represent a gradient of chemical contamination in the sediment. Liver and bile samples were collected from all fish and are being analyzed to identify those biomarkers which, when used in concert, best define the level of exposure to contaminants at a site. The results of these studies will help identify and evaluate new biomarkers of contaminant exposure and early biological effects for inclusion into future monitoring and damage assessment studies.

Effects of Contaminants on Reproductive Success

A 2-year study evaluating the effects of exposure to xenobiotic compounds on ovarian development in English sole was concluded. In this study of four Puget Sound sites, female English sole collected during the spawning season at heavily contaminated sites were found to be significantly less likely to undergo gonadal maturation and had lower mean levels of plasma estradiol (a hormone involved in control of gonadal maturation) than females from less contaminated sites. The increased risk of inhibited ovarian development was strongly associated with elevated levels of liver AHH activity. Moreover, this enzyme activity was correlated with concentrations of CHs in liver and PAH metabolites in bile of the female English sole.

Field and laboratory studies assessing the effects of chemical contaminants on the reproductive success of English sole continued during 1988. One major objective of this program is to identify biological and biochemical indicators of reproductive success. In the laboratory component of these studies, gravid female English sole from a nonurban site (Port Susan) and from three urban sites (the Duwamish Waterway, Eagle Harbor, and Sinclair Inlet) were brought to the laboratory and treated with a hormone to induce spawning. The proportion of females that spawned was significantly lower

for sole from the three urban sites than for similarly-treated sole from the reference site. Moreover, similar to the findings on ovarian maturation, spawning success was positively correlated with plasma levels of estradiol. Because estradiol plays a critical role in ovarian maturation and may also be involved in the spawning process, and because its metabolism can be altered by exposure to contaminants, it may be a useful monitoring tool in field studies designed to investigate the impact of contaminant exposure on reproduction in marine fish.

As a direct consequence of extensive studies with English sole from Puget Sound, field studies assessing the effects of chemical contaminants on the reproductive success of winter flounder along the New England coast were also undertaken. These studies involved sampling winter flounder from nonurban and contaminated sites from Boston Harbor, Massachusetts, to Long Island Sound. Tissue samples from gravid females were taken for histological and biochemical analyses, including determination of the stage of ovarian maturation, hepatic AHH activities, levels of DNA adducts in liver, and plasma estradiol levels. The results of these studies will provide important information on the effects of chemical contaminants on the reproductive processes of a commercially important benthic fish species from the east coast. The results of these studies on reproductive dysfunction can be used to evaluate the effects of contaminant exposure at the population level and assessment of the impact of contaminants on fisheries resources.

Sediment Toxicity Bioassays

Sediment bioassays are used extensively in tests of dredged sediments to evaluate disposal options, but most available bioassays address only acute and lethal effects. New assays for assessing chronic effects as well as sublethal effects are needed. EC staff developed toxicity bioassays of marine sediments using larval or juvenile stages of four different marine organisms to evaluate their dose-responsiveness and sensitivity of selected measures of lethal and sublethal effects. Test species included surf smelt (*Hypomesus pretiosus*), sand dollars (*Dendraster excentricus*), a tube-building polychaete (*Neanthes arenaceodentata*), and a sediment-burrowing polychaete (*Armandia brevis*). Sediment samples were obtained from three polluted sites in Puget Sound which varied in degree and nature of contamination. Duration of the bioassays ranged from 96 hours to 28 days, depending on the species tested. Generally, dose-responsiveness in relation to chemical exposure was observed for both lethal and sublethal measures of toxicity. In all cases, sublethal measures of growth (i.e., length, weight, or biochemical parameters, such as cellular content of DNA and proteins) appeared to be much more sensitive measures of toxicity than lethality. These findings indicate that reliance on lethality as the sole measure of toxicity would underestimate the potential deleterious effects of contaminated marine sediments. Moreover, sub-

lethal indicators of effects not only provide increased sensitivity but offer opportunities to assess long-term effects of exposure of marine organisms to contaminated sediments.

Analytical Chemistry

A manual describing a new, cost-saving method for improving the efficiency of chemical analysis of organic compounds was adopted by NOAA's National Status and Trends Program during 1988. A critical step in preparing samples for analysis is extracting the sample with organic solvents and removing interfering materials from the resulting extracts. The extract cleanup, critical for accurately identifying and quantifying the chemicals of interest, has also been highly labor intensive and, therefore, has been one of the most expensive components of the analytical procedure. The new method, employing high-performance liquid chromatography, lends itself to automation, saves substantial time and materials, and provides greater precision and better data. This technique is currently being upgraded to include additional toxic chemicals or compounds indicative of sewage contamination.

A multiyear laboratory intercalibration study involving PAHs in marine sediment was concluded. A major achievement of this study was a several-fold reduction in variability for PAH concentrations as measured by established laboratories. Adoption of laboratory "standard methods" developed by Division chemists accounted for much of the improvement in interlaboratory precision. Intercalibration of laboratory results is essential for quality control in chemical analyses and more rigorous environmental monitoring.

Division scientists have continued research on the toxicant tributyltin (TBT), used as an antifouling agent in the bottom paint of vessels. Butyltins were detected in both sediment and liver tissue at a number of Puget Sound sites, including one in the Duwamish West Waterway, an area of intense industrial activity. No butyltins were detected in sediments from President Point, a nonurban site. These results were obtained as part of a study evaluating the accuracy and utility of analytical procedures and to assess conditions in Puget Sound. Another study was carried out as a cooperative project with the Seattle District's U.S. Army Corps of Engineers to investigate the extent of TBT contamination in sediment collected in or near selected marinas and harbors. This study used procedures developed by Division scientists for measuring TBT and other butyltin compounds in marine sediments. The results of these studies will aid management decisions regarding TBT contamination in Puget Sound.

Cooperative Activities

Division scientists regularly interacted with other Federal and state agencies, including the Environmental Protection Agency, the U.S. Army Corps of Engineers, the Washington State Departments of Ecology and Fisheries, and the Puget Sound Water Quality Authority, regarding research priorities and planning of regulatory and remedial action in Puget Sound and other estuaries around the nation. Division scientists also played a major role in the preparation of NOAA's Coastal Ocean Initiative.

1988
ORGANIZATION CHART

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NOAA National Analytical Facility

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UTILIZATION RESEARCH (UR) DIVISION

The UR research activities are directed toward the study of concepts that will generate information useful for obtaining maximum use and value from fishery resources. In addition to conducting research on preservation, product quality and safety, waste utilization, fish oil fractionation and purification, and fish proteins, the UR staff serves as a source of information on fishery technology to a wide variety of government, academia, and industry clients, as well as the general public.

Resource Utilization

Research on the use of an inhibitor to prevent enzyme degradation of fish muscle protein has provided the key to preparing surimi from Pacific whiting (*Merluccius productus*). During 1988, the first commercial scale production of crab analog using Pacific whiting surimi was made from whiting surimi produced by UR. The successful production of the crab analog was made possible by the incorporation of an inhibitor for the protease enzyme(s) present in Pacific whiting parasitized by the myxosporean *Kudoa* sp. The preparation of crab analog in the commercial plant consisted of 100% Pacific whiting surimi. No processing problems were encountered in any of the processing steps.

The use of the enzyme inhibitor and the method of its preparation are the subjects of a patent application prepared and filed during 1988.

The research efforts at the Kodiak Field Station were shifted somewhat during 1988 to include more emphasis on the flatfishes. There are several species of flatfish including yellowfin (*Limanda aspera*), rock (*Lepidopsetta bilineata*), rex (*Glyptocephalus zachirus*), flathead (*Hippoglossoides elassodon*), and Dover (*Microstomus pacificus*) sole that have good potential for further domestic development. The work at Kodiak is providing data on keeping quality, chemical properties, and sensory characteristics of these species. The research is being done cooperatively with the Fishery Industrial Technology Center, the Alaska Fisheries Development Foundation, and the fishing industry.

In addition to the laboratory research projects at Kodiak, the staff continues to be active in the role of advisor to the Alaskan fishing industry. During 1988, the group participated in several industry workshops on the following subjects: 1) fish block and fillet standards; 2) in-plant sanitation; 3) halibut quality; and 4) waste utilization.

Product Quality and Safety

The safety and wholesomeness of seafoods are always important to the industry and consumer as well as to regulatory agencies. The UR Division has gained worldwide recognition for research in the area of *Clostridium botulinum* and prevention of toxin production in seafoods. During 1988, research was completed on a heat-pasteurization process for processing of vacuum-packaged, hot-smoked fish. The process is useful for increasing the refrigerated storage life of hot-smoked fish and at the same time reducing the amount of NaCl or other inhibitors required for safety and preservation. The process is applicable to products that are prepared from fillets, steaks, or other sections of fish, but somewhat less applicable to products prepared in the eviscerated form such as trout and chubs. When the latter species and forms are processed by the technique, the flesh tends to separate from the bone. When the process is used, it enables the processors to smoke fish at a lower temperature prior to heat-pasteurization treatment. The final product must be stored at refrigerated temperatures below 38°F.

In the area of microbiological safety of fishery products, a recent development has caused the UR Division to shift some emphasis to another research area that involves the foodborne pathogen *Listeria monocytogenes*. The recent isolation of *Listeria* from several ready-to-eat fishery products has caused a great deal of concern among regulatory agencies and the industry. In response to the need for accurate data regarding the potential hazards of the organism in seafoods and for reliable methods of controlling growth, the Division has initiated a program of research on *L. monocytogenes*. Research areas that are currently being studied include: incidence of *Listeria* in different raw and ready-to-eat fishery products, growth of *L. monocytogenes* in refrigerated products, and methods of inactivating or inhibiting this bacterium. *Listeria monocytogenes* is widespread in nature and grows at temperatures as slow as 36°F. The effect of salt and other preservatives on the inhibition of *L. monocytogenes* is currently being studied with smoked fishery products. A pasteurization process for the inactivation of the organism in crab and shrimp is being developed and a recommendation for cooking (reheating) of crab in the shell has been made; the industry is modifying labels on such products to include this recommendation. Good manufacturing practice guidelines will be developed for the different products based on these and other studies.

Fish Waste Utilization-Aquaculture Nutrition

Research has been conducted during the last year on mineral requirements of juvenile salmon and on carotenoid pigment absorption, excretion, and deposition. The dietary mineral requirements of salmonids are an important consideration when using

products made from fish processing waste in fish diets because fish processing waste is generally very high in ash or mineral content. The ash content of fish processing waste can be reduced to levels well below those found in fish meats, but the optimum levels to reduce ash in these products is difficult to determine because the dietary mineral requirements of salmonids are not well understood. Complicating the study of dietary mineral requirements in fish is the contribution of dissolved minerals in the water in which fish are reared. It is well known that fish can derive certain minerals from rearing water, but for many minerals dietary input is needed as well.

Several studies involving potassium and magnesium have been completed. Research showed that juvenile chinook salmon require approximately 0.8% potassium in their diet to maintain normal body levels and to prevent deficiency. While the research showed that the fish could obtain potassium directly from their rearing water, dietary supplementation was required. The dietary magnesium level found to support normal growth and whole body magnesium concentrations was found to be .06% of the diet, although a higher dietary level was predicted from dose-response curves.

Carotenoid pigmentation of salmon grown for market is an expensive proposition, in part due to the low retention of dietary carotenoid pigments in the flesh. Retention is estimated to be approximately 4.6%. It is not known whether low retention is the result of low absorption of pigments by the fish, or the result of low deposition once pigments are absorbed. Two studies were conducted to measure absorption, deposition, and excretion of synthetic canthaxanthin by rainbow trout. The first study was designed to measure intestinal absorption of canthaxanthin by conventional digestibility methods, in which dietary input and fecal excretion are measured. Using this approach, the effects of dietary canthaxanthin and dietary fat levels on canthaxanthin digestibility were determined. The results of the study indicated that digestibility decreased as dietary canthaxanthin levels increased. Dietary absorption increased when dietary fat levels increased. However, the sensitivity of this method for estimating carotenoid pigment absorption was relatively poor. The second study involved feeding fish canthaxanthin labelled with ^{14}C . Ninety-six hours after feeding the fish were sacrificed and the distribution and levels of ^{14}C in various tissues were determined. The results of this study showed that canthaxanthin was absorbed at a rate much higher than it is retained in the tissue, and that canthaxanthin is metabolized and excreted in the bile.

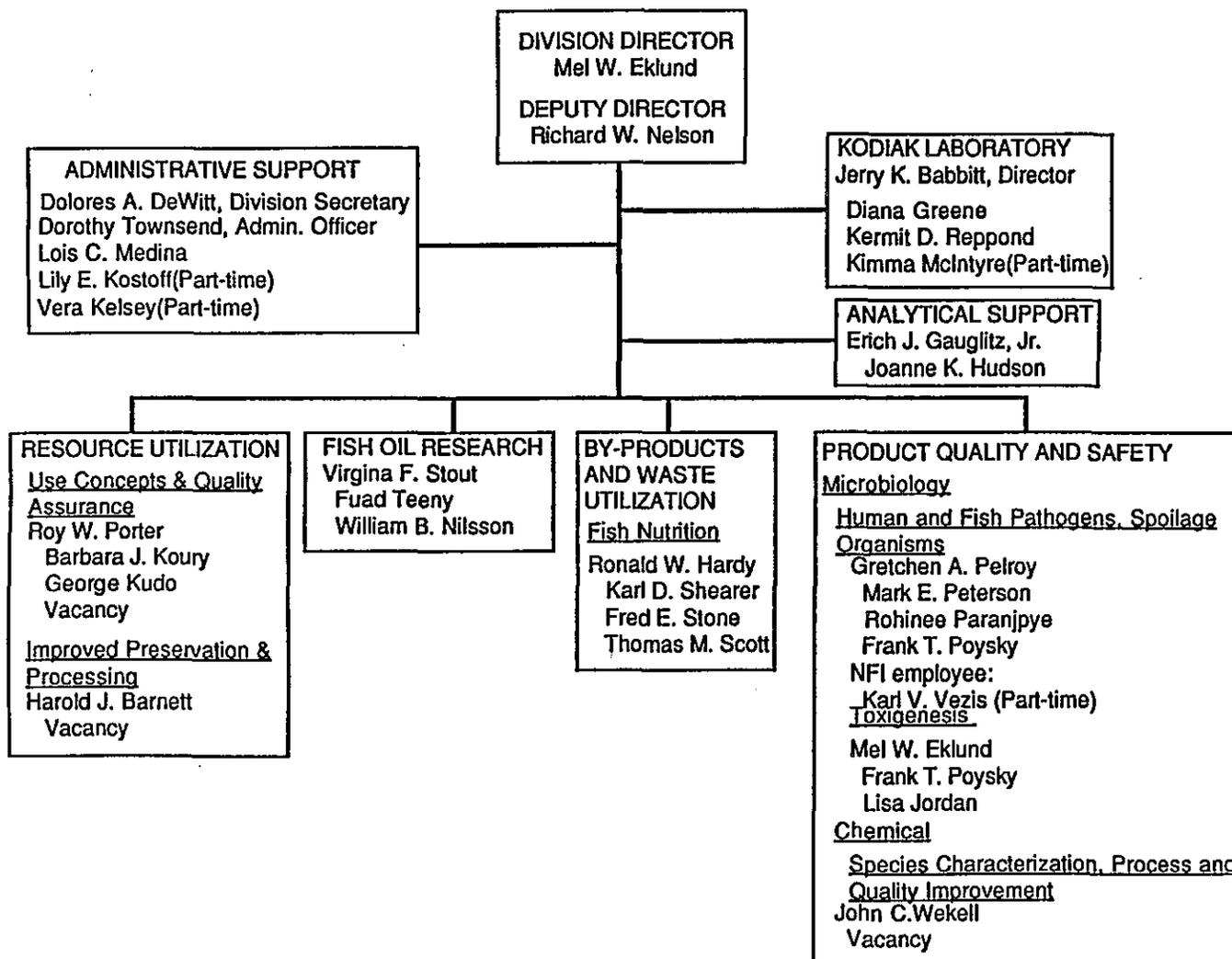
Fish Oil Research

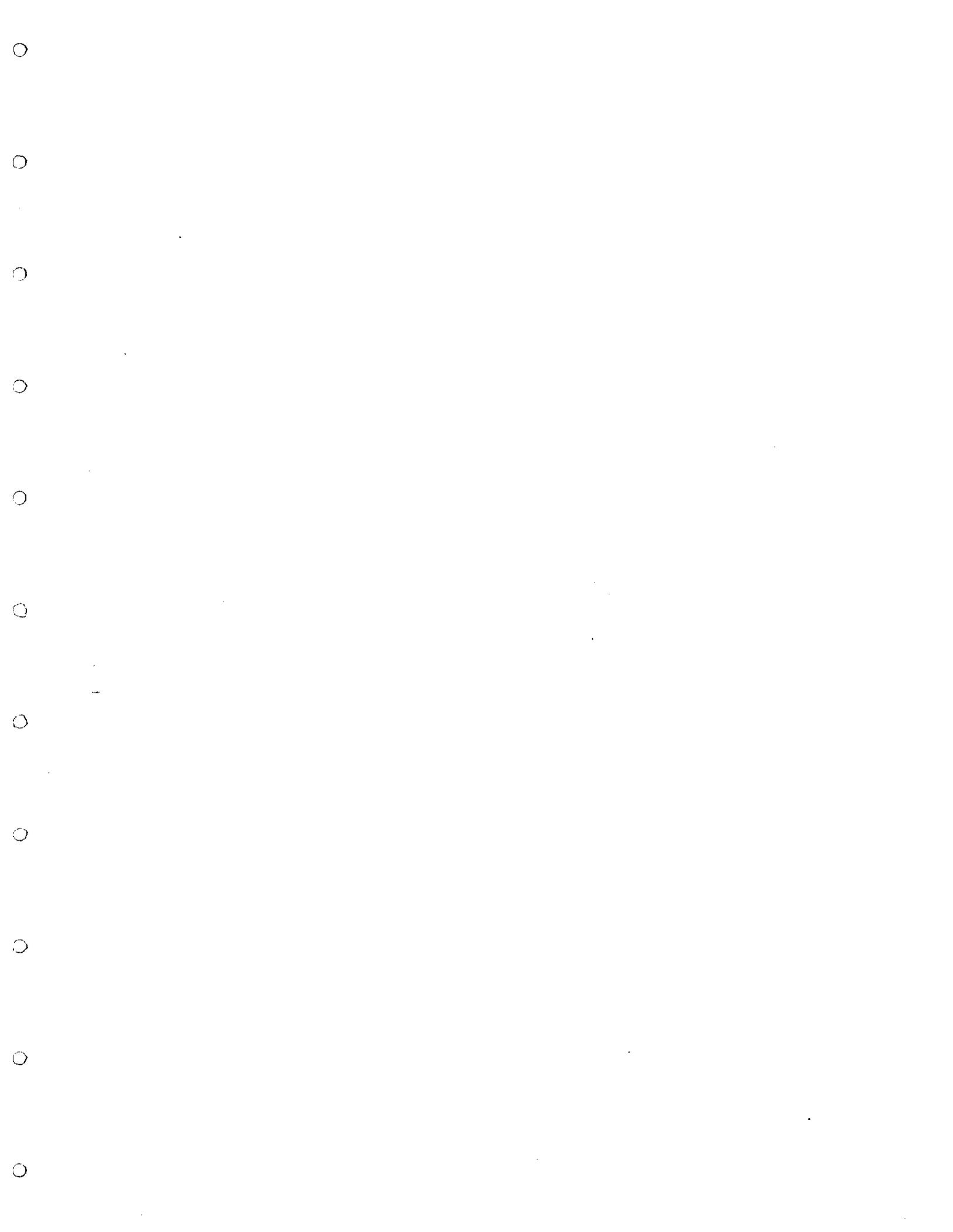
The development of two processes to achieve high quality fish oil and the two omega-3 fatty acids, eicosapentaenoic (EPA) and docosahexaenoic (DHA), considered to be the most likely related to the physiological activity of fish oil, have been previously reported by the UR Division. During 1988, the fish oil research group completed the

design, procurement, and installation of a unit which produces up to 10 pounds per day of EPA and DHA. The unit was installed at the Charleston UR Laboratory, Charleston, South Carolina.

Following completion of the scaled-up supercritical fluid carbon dioxide extraction unit, the researchers turned their attention to the development of techniques to produce omega-3 compounds in the form of triglycerides--the form found in natural fish oils. In previous work, the omega-3 fatty acids were converted to esters because of the more efficient recovery in ester form. Since the ester form of the omega-3 compounds is an unnatural form of the fatty acid, the question of spurious results in physiological evaluation becomes an important one. The Fish Oil Research Program has been investigating new methods for converting individual omega-3 compounds back into the natural triglyceride form. The research has been successful and substantial quantities of the desired individual omega-3 triglycerides have been prepared. Supercritical carbon dioxide extraction has been used to purify the crude reaction mixtures. The new technology is especially effective in sorting excess starting esters from intermediate mono- and diglycerides and the desired triglyceride product.

**NORTHWEST AND ALASKA FISHERIES CENTER
UTILIZATION RESEARCH DIVISION**





ALASKA SCIENCE CENTER DIRECTOR'S OFFICE

The Alaska Science Center Director's Office (ASCDO) provides the overall leadership and administrative control for the full range of activities within the Alaska Fisheries Science Center. This office encompasses a series of Center support functions, including computer systems, graphics, publications, and the library services.

The ASCDO administers the following important areas of Center involvement:

1. Fishery Management Councils - represents the Alaska Center at meetings of the International North Pacific Fisheries Commission (INPFC), the North Pacific Fishery Management Council (NPFMC), and the Pacific Fishery Management Council (PFMC).
2. Academia - cooperates with area universities, including the College of Ocean and Fishery Sciences at the University of Washington in Seattle, and the University of Alaska and various Sea Grant programs.
3. Fishing Industry - keeps close ties with industry by attending meetings of industry groups and industry-sponsored symposiums and workshops.

Additionally, the Alaska Center Director's Office may direct special-purpose, multi-disciplinary programs extending beyond the Alaska region.

Marine Entanglement Research Program

During 1988, the National Marine Fisheries Service acquired new responsibilities to control marine debris through the enactment of two new federal laws, the Marine Plastic Pollution Research and Control Act of 1987 and the Driftnet Impact Monitoring, Assessment and Control Act of 1987. The Marine Entanglement Research Program (MERP), in consultation with the Environmental Protection Agency, Department of Transportation, and other agencies, has developed public awareness programs to meet the requirements of the first Act.

In 1988, MERP coproduced an award-winning video entitled "Trashing the Oceans" describing the marine debris problem; opened public service Marine Debris Information Offices in Washington, D.C. and San Francisco, California; chaired the third meeting of the National Marine Debris Roundtable and a session of the "Oceans of Plastic" conference in Portland, Oregon; and cochaired a NMFS-sponsored national meeting on Northern fur seal research. Program staff advised the U.S. delegation to the Inter-

national Maritime Organization (IMO); acted as NOAA advisor on the formulation and activity of the Interagency Task Force on Persistent Marine Debris; and assembled the steering committee for the Second International Conference on Marine Debris. MERP staff helped draft and review the "Interagency Task Force Report on Persistent Marine Debris" which is used to form federal policy and action plans on the marine debris problem.

During 1988 the MERP undertook a variety of actions to assist in the implementation of MARPOL Annex V in the United States. A major accomplishment in this area was the official adoption by the IMO of the "Guidelines for the Implementation of Annex V of MARPOL 73/78," drafted by the MERP. This document will be published and made available to all maritime nations, providing practical advice on research, education, technology, and regulations for the long-term realization of the goals of Annex V. Further, the MERP manager acted as Federal Program Officer for Saltonstall-Kennedy (S-K) actions and three Program-initiated grants aimed at developing information to assist ports to comply with MARPOL Annex V.

The Program manages the NMFS research program under the Driftnet Impact Monitoring, Assessment, and Control Act of 1987, and during 1988 oversaw the production of the first report to Congress on the nature, extent, and the impacts of high seas driftnet fishing on resources of interest to the United States.

Office of Fisheries Information Systems

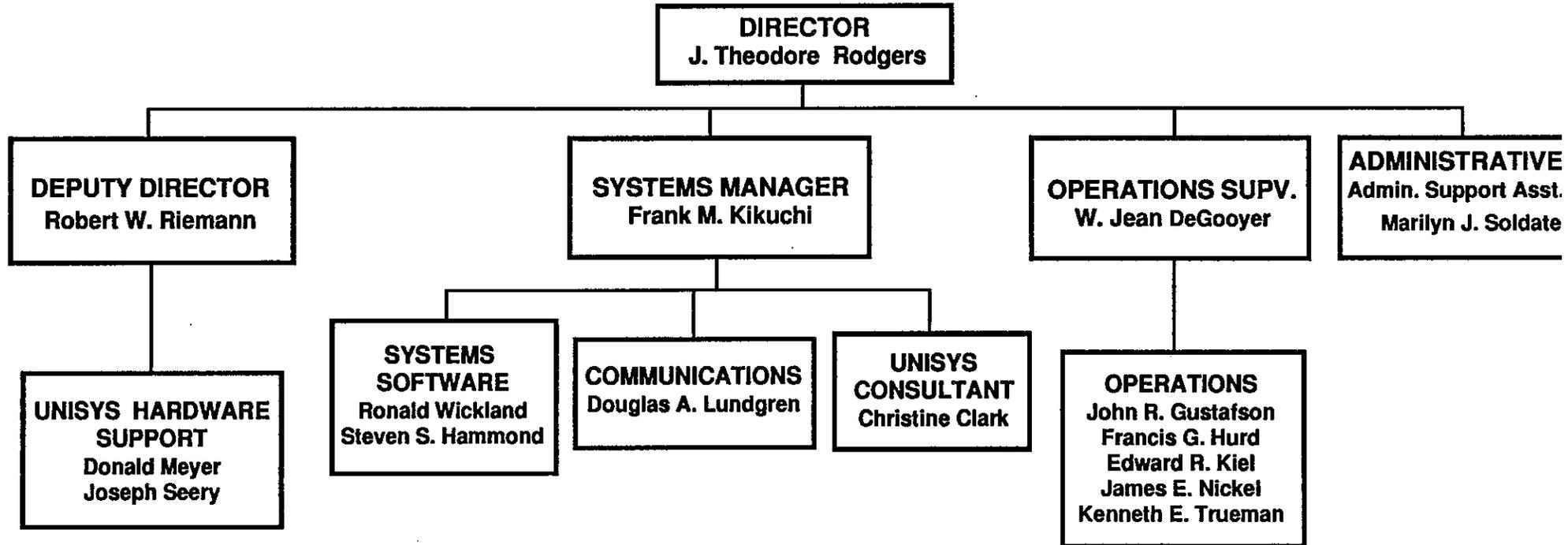
The IT-95 computer acquisition project which will ultimately replace the Burroughs B7800 was strongly supported by OFIS on several levels. Bob Riemann, Deputy Director, was named national benchmark team leader and Frank Kikuchi, Chief Systems Staff was instrumental in creating several of the most significant benchmark tasks which will help size the new computer system.

OFIS staff implemented a new version of the Burroughs Master Control Program operating system which involved extensive planning and testing. While achieving several significant improvements in B7800 operation this is the final update which is supported by UNISYS for this machine.

A Memorandum of Agreement with the U.S. Bureau of Mines in Denver, Colorado, was established for mutual contingency computer support. As a result, OFIS has installed and tested electronic switch gear for communications by BOM terminals and remote stations in Denver and Washington, D.C.

Bob Riemann served as Acting Director of the Center's OFIS group and Regional Data Base Administrator for 7 1/2 months until the new Director came on board. Ted Rodgers was hired as the new OFIS Director effective 15 August. He comes from General Services Administration in Auburn, Washington, where he held a variety of positions in ADP management.

OFIS ORGANIZATION CHART



AUKE BAY LABORATORY (ABL)

Research Accomplishments

U.S.-Canada Salmon Treaty

The U.S.-Canada Salmon Program provides annual information on long-standing Pacific salmon (*Oncorhynchus* spp.) management issues involving interception in salmon fisheries of the United States and Canada. The information provided is used to balance the catch of each nation's salmon in the fisheries of northern British Columbia and Southeast Alaska. Program staff conducted research with Canadian and Alaska State counterparts on stock identification, assessment, and analyses of fisheries occurring in boundary areas, transboundary rivers, and coastal areas. A cooperative agreement with the Alaska Department of Fish and Game (ADF&G) for Pacific Salmon Treaty studies was established and monitored. ABL scientists provided technical support to U.S. negotiators working with Canadian counterparts under the Pacific Salmon Treaty. Six ABL biologists also served as Technical Committee members on panels of the Pacific Salmon Commission.

Reducing Interceptions of American Salmon by Foreign Gill-net Fleets

The High Seas Salmon Task (under the Marine Resources Program) estimates numbers of U.S. salmon intercepted on the high seas by foreign fishing fleets, and advises U.S. negotiators on high-seas salmon issues. During 1988, Dr. Michael Dahlberg was appointed the U.S. member of the Subcommittee on Salmon of the International North Pacific Fisheries Commission (INPFC); he was also the scientific advisor to U.S. Commissioner Tillion and the lead negotiator in talks with Japan regarding suspected underlogging of salmon catches in the 1986 mothership fishery and the need for expanded U.S. observer coverage of the mothership fishery in 1988. Advice for changing time and area regulations in the Japanese, Taiwanese, and Republic of Korea (R.O.K.) squid fisheries (to minimize interceptions of salmon of North American origin) was provided to the Department of State and was used for negotiations with those countries. Catch-effort trends were reported to the ADF&G and National Marine Fisheries Service Alaska Regional Office during 1988, although there was no direct observer coverage of the fishery.

Reports were submitted to INPFC and the U.S. Section of the INPFC was briefed on the Japanese high seas driftnet fisheries and their impact on North American salmonid stocks.

A scientific rebuttal from the National Oceanic and Atmospheric Administration (NOAA) was prepared in response to the Japanese proposal to extend the northern boundary of its high seas squid driftnet fishery during July and August.

The proportion of Pacific salmon of U.S. origin occurring in long. 2° by lat. 5° statistical areas throughout the North Pacific Ocean was estimated for use by the Department of State in developing the Rebuttal Presumptions Policy that would extend U.S. management authority for the United States of salmonid resources beyond the Exclusive Economic Zone (EEZ).

In 1988, the Task trained and placed scientists aboard Taiwanese, R.O.K., and Canadian research vessels and a commercial R.O.K. squid vessel. A series of long negotiations with Japan resulted in agreement on an observer program on commercial vessels but was thwarted in June by a U.S. Supreme Court ruling against the Department of Commerce (DOC). The National Marine Fisheries Service's (NMFS) Office of International Affairs was advised throughout the year on observer and data requirements in on-going negotiations with Japan, Taiwan, and the R.O.K.

ABL helped sponsor a workshop on North Pacific squid resources that was attended by U.S. and Canadian scientists.

Alaska Groundfish Stocks

ABL's Marine Resource Program ecology staff provides data for status-of-stock evaluations by collecting information on abundance, distribution, and biology of sablefish (*Anoplopoma fimbria*), rockfish (*Sebastes* spp.), and other selected species in the Gulf of Alaska; the Marine Groundfish Analyses staff provides estimates of yield and potential exploitation of groundfish stocks in the Gulf of Alaska to the North Pacific Fishery Management Council (NPFMC) and INPFC.

Domestic commercial and foreign research vessels ran sablefish longline surveys in the eastern Gulf of Alaska during the summer of 1988. ABL scientists participated in both surveys. Hook type, gangion spacing, and radio tracking experiments with Southeast Alaska sablefish contributed to our understanding of the factors affecting sablefish longline catch rates. ABL continued to tag juvenile sablefish in the Sitka area, and search for additional sites of abundance (particularly in the Prince of Wales area). New research to assist the Alaska Fisheries Science Center's Research Ecology and Fisheries Management Division (REFM) Ageing Unit's verification of sablefish age determination was undertaken with more than 6,000 OTC (oxytetracycline) marked fish released.

Salmon Enhancement

The Salmon Enhancement Program provides enhancement technology to public and private production facilities in Southeast Alaska. ABL's research is part of an annually updated multiagency chinook salmon (*O. tshawytscha*) enhancement plan. One research priority is to accurately document numbers of chinook salmon entering the fisheries from Alaska enhancement projects so that the effectiveness of mitigation efforts in increasing treaty mandated catch quotas can be determined.

Chinook enhancement research continued at Little Port Walter (LPW). Analyses were completed of 5,800 adult chinook wire tags collected from adults returning to LPW in 1987 and from 4,500 adult chinook returning in 1988. A total of 190,000 1987-brood smolts were coded-wire tagged for release in spring 1989. The LPW chinook stock was a major contributor to the 1987 and 1988 winter and summer troll fisheries, including terminal area experimental fisheries designed to target on returning hatchery adults. Analyses of past ocean survivals, including fishery contributions and return rates to LPW of several broods of Unuk stock chinook, have provided a predictive model for releases of yearling smolts of this stock. Beginning with 1988-brood, a new chinook stock from the King Salmon River will be cultured and released at LPW. The ultimate goal of this program is to provide eggs from this stock for use at several other facilities in northern Southeast Alaska.

ABL sponsored the 1987 Alaska Chinook Salmon Workshop held 14-15 April 1987 in Juneau (NWAFC Processed Report 88-06, June 1988). This workshop included 37 technical reports on Alaska and British Columbia chinook salmon biology, management, restoration, and enhancement.

The cooperative study between ABL, the University of Alaska, and ADF&G, designed to rebuild the depressed Auke Creek sockeye salmon (*O. nerka*) run, is ahead of schedule. Four groups of marked 1987 brood fry and smolts totaling 150,000 fish were released either into Auke Lake or Auke Bay in 1988. The experiments to identify the most effective restoration technology include age-0 smolts. About 150,000 1988-brood sockeye eggs were collected for age-0 smolt releases in 1989.

Early Ocean Chinook Salmon

Under the U.S.-Canada Treaty, chinook salmon caught incidentally after specified quotas have been reached must be released. ABL is studying hooking mortality of chinook salmon caught incidentally by coho fisheries. New research in 1988 examined the feasibility of modified fishing gear including hook-and-lure sizes and shapes for reducing hooking mortalities. Two data sets have been completed on hooking mor-

tality of legal and sublegal size chinook salmon caught on conventional commercial troll gear. Analyses of these data revealed specific hook-lure combinations that can effectively reduce mortality of hooked-and-released chinook.

A study using chartered commercial trollers and specialty fishing gear to capture juvenile chinook and coho salmon during their first few months at sea is in progress. An important early finding of this study was the determination of migration paths of both Alaska and non-Alaska chinook stocks through inside and coastal marine waters of Southeast Alaska. Early Ocean Salmon Program staff continued work on the Auke Bay Salmon Recruitment Study. This study provides new insight into the early marine residence timing, migration patterns, food requirements, and eventual ocean survival for temporal run components of a specific pink salmon (*O. gorbuscha*) stock. Techniques developed in this study were applied in early 1989 toward determining the effects of the Prince William Sound oil spill on outward migrating juvenile salmon.

Habitat Assessment

In an effort to resolve management issues between the United States and Canada, Habitat Assessment staff members separated sockeye salmon stocks of U.S. origin from Canadian stocks by examining fish for the presence of the myxosporidian brain parasite, *Myxobolus neurobius*. Nearly all sockeye in lake systems are parasitized, whereas few fish were parasitized in riverine habitats. The percentage of parasitized fish remains constant from year to year in a given system. The parasite does not affect host salinity tolerance or growth, but does reduce swimming stamina. Studies of indigenous parasites also show promise for separating American from Asian stocks.

In 1987 and 1988, cooperative research with the U.S. Forest Service and ADF&G was conducted on the Situk River to determine the potential effects of flooding (caused by the closing of Russell Fiord due to the advancement of Hubbard Glacier) on juvenile and adult salmon. Habitat field researchers defined distribution, abundance, habitat usage, and the significance of age-0 chinook and sockeye smolts in the Situk River, as well as the spawning distribution, timing, and habitat characteristics of adult chinook and sockeye salmon in the Situk River.

As part of the Entanglement Program, ABL continued Alaskan beach surveys for net and plastic debris. The distribution, rates of accumulation, and disappearance of derelict fishing gear that may be harmful to marine mammals and birds were determined from surveys of 21 Alaska beaches. Since 1972, a total of 60 km of remote outer coast beaches have been periodically surveyed to determine type, source, quantity, and deposition of plastic debris washed ashore. Most (60%) debris washed ashore is fishing gear, of which rope and trawl web are the most abundant entanglement items. Trawl

web deposition increased at some sites, including near Yakutat (from 8.8 to 10.0 fragments/km/yr, 1985-88). Beach survey methods developed by NMFS (ABL) are used by the National Park Service to monitor debris on the east, west, and gulf coasts of the United States.

Recent ABL research on the occurrence of tributyltin (TBT) in salmon reared in TBT-coated net-pens and on concentration of TBT in bay mussels was instrumental in legislation restricting the use of TBT antifoulants in California, Oregon, and Washington; data from these studies form a baseline against which the efficacy of the legislation may be determined. A 1988 ABL study resulted in the first demonstration that imposex (i.e., one sex develops the sexual characteristics of the other) in a Pacific coast marine snail may be used as an extremely sensitive yet inexpensive biological indicator of TBT in seawater; the resulting imposex decreased with distance from marinas and was induced by low parts per trillion exposures.

The Habitat Lab Unit determined the habitat and environmental requirements of larval, juvenile, and adult red king crabs. This included defining the habitat preferences and relationship of cannibalism to availability of food for two age classes of juveniles. The timing, depth, and habitat preference of the first juvenile stage was determined by placing experimental collectors in the environment. Seasonal movements of adult female crabs were determined by sonic tagging and tracking.

NATIONAL MARINE MAMMAL LABORATORY (NMML)

In January 1988 the NMML initiated a 5-year plan to meet the following research and management needs: 1) determination of the survival rate of bowhead whale year classes up to age and size at sexual maturity, and creation of an independent measure of population abundance; 2) determination of the trends and causes of population changes in northern fur seals and northern sea lions; 3) determination of the distribution, population abundance, feeding behavior and incidental take of harbor seals, harbor porpoise, and California sea lions in Washington State; 4) identification of oceanographic processes and the distribution, abundance, and feeding behavior of marine mammals in relation to coastal and high-seas fisheries; and 5) examination of the reproduction and feeding ecology of Antarctic fur seals, southern elephant seals, crabeater seals, and penguins near the Antarctic Peninsula.

Bowhead Whale Research

Research on bowhead whales (*Balaena mysticetus*) in 1988 focused on the analysis of the 1982-87 data base. One thousand three hundred forty-six individually identified whales were compared for among-year resightings resulting in a population estimate of 5,538 - 3,775 (95% confidence intervals). Length measurements of 1,263 whales suggest that the proportion of adults (13 m) in the population is about 40-45%, with calves accounting for 1.2 to 15.0%. The 3-year data base (1985-87) suggests that there is wide variability in recruitment between years. The importance of this variability in recruitment to recovery of the species is unknown. Also, during 1988, 10 baleen plates were analyzed at Texas A&M for carbon isotope ratios in an effort to estimate ages of animals. Preliminary results suggest plates of differing lengths from the same animal give varying carbon ratios (i.e., presumed ages), casting further doubt on this method as an ageing tool.

Gray Whale Census

A full gray whale (*Eschrichtius robustus*) census was conducted in 1987-88. Assisted by the Southwest Fisheries Science Center (SWFSC), a double counting experiment and aerial surveys were conducted to determine the proportion of missed whales. Using a new model, the estimate of absolute abundance is 21,113 (standard error 688). Final analysis of the 1987-88 census, including sampling discrepancies and trends in abundance, will be completed in 1989-90 in preparation for the 1990 International Whaling Commission meeting.

Humpback Whale Photoidentification System

In 1988, nearly 5,000 humpback whale (*Megaptera novaeangliae*) fluke patterns were entered into a PC-based system and cross-matching was conducted from photographs submitted by researchers in the North Pacific. Improvements in software, test matchings, and a user's guide were developed.

Northern Fur Seals

In 1988, the Laboratory conducted sampling of northern fur seal (*Callorhinus ursinus*) rookeries on St. Paul and St. George Islands, with the assistance of St. Paul residents, to identify the number of bulls and estimate pup production. The estimated number of pups born on St. Paul Island (202,300) was approximately 18% higher than in 1987, significantly greater than each year since 1982. Pup production on St. George Island declined 13.8% from 1985 (28,900) to 1988 (24,900). The count of idle bulls was up 70% on St. Paul Island over 1987, reflecting the recent halt of the commercial harvest, but down 2% on St. George Island. Harem bull counts on St. Paul Island were the same as in 1987 but down another 3% on St. George Island. The colony of fur seals on Bogoslof Island is growing rapidly, increasing from two animals in 1978 to 449 (including 80 pups) in 1988. Pup production on San Miguel Island was similar to that in 1987, but is still about 29% below the numbers observed prior to the 1982-83 El Niño warm water event.

A preliminary assessment of predation on fur seal pups by northern sea lions in 1988 suggests that the predation rate has dropped four-fold since 1975, from 3.4 to 2.2% of pups born. No significant disease processes were found in our long-term study of pup mortality (91 collected in 1988). Aerial photographs taken in 1988 are being compared to historical photographs (back to the 1940s); they show a dramatic decrease in the amount of space being used today by territorial and bachelor male fur seals.

A total of 53 debris-entangled subadult fur seals and 106 controls were tagged on St. Paul Island in 1988 to study long-term survival. Of these, 30 (15 of each group) were fitted with radio transmitters to study within-season on-land and at-sea movements and behavior. This cooperative effort with Japan evaluated the feasibility of continuing to assess tagging as a means of estimating mortality of entangled animals. Analysis of the results indicated that tagging will not, in all likelihood, provide statistically reliable sample sizes to precisely estimate mortality; thus, tagging (flipper tags and radio tags) of debris-entangled animals has been terminated. The rate of entanglement of northern fur seals on land decreased for the first time since our studies began in 1981; the rate in 1988 was 0.28%, compared to the previous 8 years which averaged about 0.40%.

Japanese scientists reported that the rate of debris found at sea in 1988 was 50% lower than in 1987, which may explain the reduced numbers of entangled fur seals.

Northern Sea Lion Studies

Northern sea lion (*Eumetopias jubatus*) research in 1988 was conducted on Marmot Island, Alaska. Pup production was the same as 1987 (about 3,000), but approximately 27% less than in 1986, 46% less than in 1984, and 53% less than in 1979. Counts of adult animals (3,206 in 1988) parallel the decline in pup production: about 36% less than 1985 and 50% less than 1979. (Overall, the population in the eastern Aleutian Islands and Gulf of Alaska--the central portion of the species' range--has declined 52% since the early 1970s.) Sixteen adult females were experimentally tested with Telazol as a tool in handling animals, with dosages of 2.5 mg/kg or less found to be most successful if administered in the muscle mass of the back or hip.

Northern Elephant Seal Studies

A total of 11,050 northern elephant seal (*Mirounga angustirostris*) pups were born on San Miguel Island in 1987-88, which is an 8% increase over the period 1986-87. In a cooperative project with SWFSC and Hubbs Research Institute, eight adult males were fitted with time-depth recorders and radio-tags to study foraging habits in and around the Channel Islands sanctuary and fishing grounds. Of the eight tagged animals, dive profiles were obtained from six. Average time at sea was 125 days; the deepest dive exceeded 1,500 m, with many deeper than 1,000 m. Most diving was virtually continuous and average at-surface time was only 4 minutes between dives lasting approximately 24 minutes each.

Killer Whale/Blackcod Interactions

The cooperative study with the long-line fleet and Greenpeace in 1988 included placing observers on fishing vessels and stationing a biologist at dock-side to interview returning crews. As much as \$2,000 per day may be lost from killer whale (*Orcinus orca*) predation on blackcod (sablefish, *Anoplopoma fimbria*) in the southeastern Bering Sea fleet. A report on the history of the fishery and interactions was completed in 1988. Preliminary results suggest that several pods of killer whales may be involved, and information and photographs of individual animals have been solicited through posters to determine the movements of whales on the fishing grounds.

AMLR (Antarctic Marine Living Resources) Program Seal Island, Antarctica

Fiscal Year 1988 was the second year of studies on the reproductive success and feeding ecology of Antarctic fur seals (*Arctocephalus gazella*), chinstrap penguins (*Pygoscelis adeliae*), macaroni penguins (*Eudyptula minor*), and cape petrels (*Daption capense*). The peak of the season for fur seal pupping and egg laying for penguins was missed; nevertheless, 125 pups were tagged, 22 adult female fur seals were fitted with time-depth recorders, and 20 were fitted with radio transmitters. Preliminary results show that female fur seals feed primarily on Antarctic krill at depths of 50-70 m. Two fur seals were tracked to 25 nmi away from Seal Island. Pup mortality increased in February 1988 and exceeded 50% for the season. The number of reproducing adult female fur seals increased 11% from 1986-87 to 1987-88.

A survey of the island revealed 3 macaroni and 67 chinstrap colonies, and 106 accessible cape petrel nests. Bad weather in January resulted in increased mortality of penguin chicks (9%) and egg loss (14%). Reproductive success was 1.29 fledglings per breeding pair of chinstrap, 0.91 for macaroni, and 0.94 for petrels. Production of macaroni penguins increased four-fold over the 1986-87 season. Temperature-depth recorders (TDRs) were attached to 10 chinstrap and 4 macaroni penguins. Depths of dives suggest they forage to 100 m. One of 40 chinstrap penguins fitted with radio transmitters was tracked 13 nmi away from Seal Island and back. The dominant prey for penguins early in the season was krill; whereas fish and squid were taken later in the season. Diet of the cape petrel was exclusively krill. In June and July 1988 we participated with the National Science Foundation's AMERIEZ (Antarctic Marine Ecosystem Research at the Ice Edge Zone) program and deployed satellite transmitters and TDRs on three crabeater seals (*Lobodon carcinophagus*).

High-Seas Driftnet Fisheries

Because of the Supreme Court's Kokechik decision regarding the incidental take of depleted marine mammal populations, no field season was conducted on Dall's porpoise (*Phocoenoides dalli*) in 1988. In addition, observers on two Japanese research vessels outside the U.S. Exclusive Economic Zone (EEZ) reported no marine mammals taken. The Dall's porpoise project in the high-seas salmon mothership fishery has been terminated, and no field studies are planned for 1989. Preliminary analysis of the 1978-86 data base suggests that the Dall's porpoise population(s) in the western North Pacific and Bering Sea have increased since 1978, although the variances are too high to detect a trend. Cooperative work with Japan supports the hypothesis that there are four separate calving areas, including the Bering Sea, south of the Kamchatka Penin-

sula, south of the western Aleutian Islands, and in the Gulf of Alaska. Studies of color patterns suggest that adult males may be distinguishable from females.

Also in 1988, a marine mammal observer was placed on a Korean commercial flying-squid fishing vessel during which 15 northern right whale dolphins (*Lissodelphis borealis*), 1 Dall's porpoise, and 2 northern fur seals (released alive) were incidentally taken. Observers were also placed on research vessels from Canada, the Republic of Korea, and Taiwan during which 7 Dall's porpoise, 1 striped dolphin (*Stenella coeruleoalba*), and 2 fur seals (released alive) were taken. Temperature-depth recorders were attached to fur seals on St. George Island in 1988 to record oceanographic features and swim speed in a preliminary study to determine the movements and feeding ecology of fur seals on the high seas. Modifications of microprocessors are being adapted to satellite beacons for possible study of the at-sea behavior of fur seals in relation to the high-seas squid driftnet and domestic fisheries.

Coastal Fishery Interactions

The incidental take of harbor porpoise in local gill-net fisheries in Washington was studied in 1988. Post-mortem examinations were performed on specimens of all ages. Two aerial surveys and one land study were conducted to assess distribution relative to coastal set-net operations. The numbers of harbor porpoise affected by the fisheries and potential impacts cannot be made until all fisheries are monitored and seasonal abundance and distribution determined.

Also, in 1988 the behavior, numbers, and predation rate of California sea lions (*Zalophus californianus*) on steelhead trout (*Oncorhynchus mykiss*, formerly *Salmo gairdneri*) were studied at the Hiram M. Chittenden Locks and in Puget Sound, as a joint project with the Washington Department of Wildlife. The number of sea lions taking steelhead increased ten-fold since 1984, while steelhead escapement declined by over 50%. Earlier mitigation measures (guard nets, seal bombs, etc.) have not been fully successful at keeping the sea lions away from the fish ladder. A capture and removal program was started in January 1989 to reduce the predation pressure on the steelhead run.

The study of California sea lions on San Miguel Island in 1988 showed a marked increase of on-land adult mortality for the first time since 1969. No fresh specimens were located, but one moribund adult female was partially paralyzed and unable to walk. The cause of these deaths is unknown.

International and Other Activities

The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

In addition to the AMLR research on Seal Island, Antarctica, mentioned above, we agreed at the Scientific Committee meeting in 1988 to co-convene the International Whaling Commission-CCAMLR workshop on baleen whale feeding ecology tentatively scheduled for 1991.

International Whaling Commission (IWC)

A NMML scientist convened an International Whaling Commission symposium and workshop in 1988 on the use of natural marks on whales for population assessments, and is co-editor of the IWC Special Issue (book series).

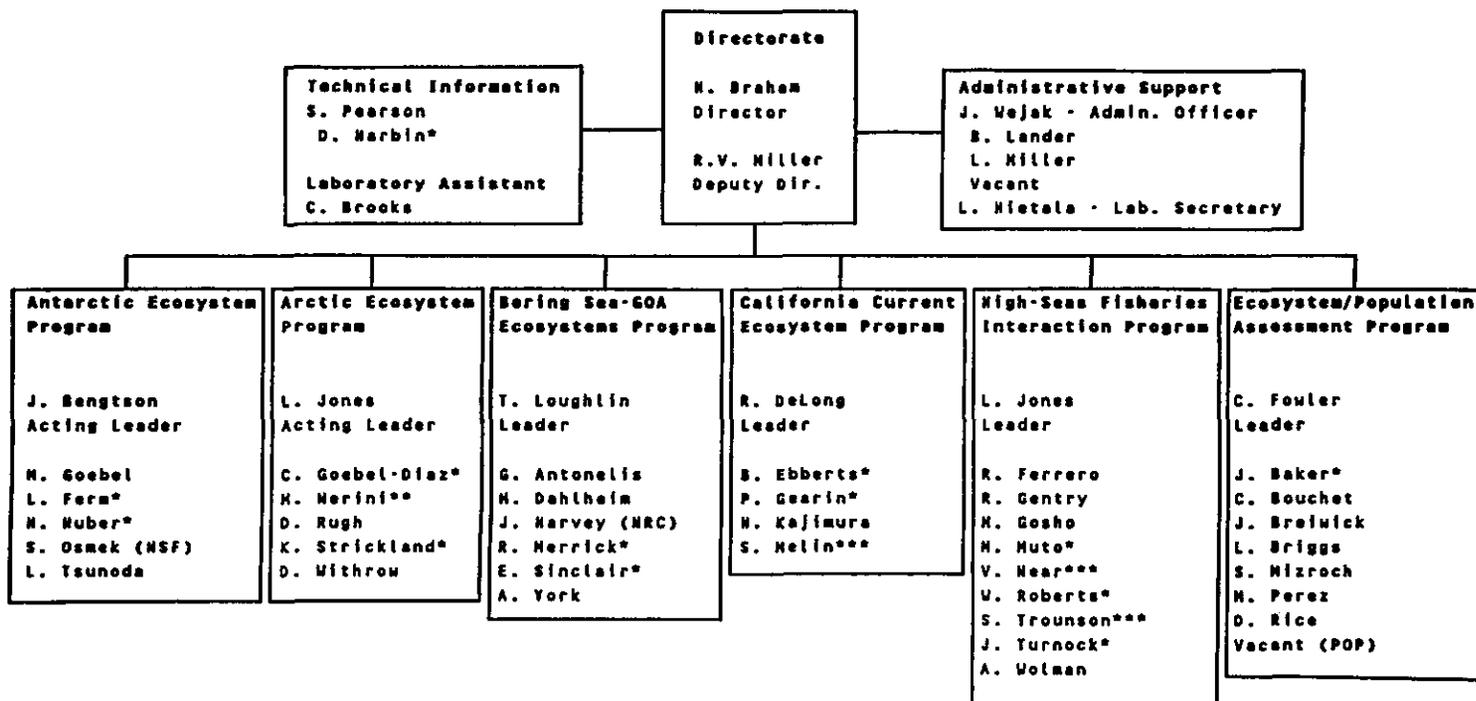
U.S.-U.S.S.R. Cooperative Agreement

The ninth meeting of the U.S.-U.S.S.R. Marine Mammal Project (Environmental Protection Agreement), was held in September 1988 in Tallinn, Estonia. There was unanimous agreement to undertake a joint survey to estimate northern sea lion abundance and status in U.S. and Soviet waters (including the Kurile and Commander Islands) in 1989 and 1990. Participants will include NMML scientists working with Soviet pinniped specialists in coordinated vessel and aerial surveys. In addition, northern fur seal research matters were included under the purview of this agreement in the absence of a multilateral treaty. And, for the first time, coastal areas in the U.S.S.R. are open for marine mammal studies; both the sea lion work in the Kuriles and extensive walrus aerial surveys and rookery studies will be carried out with American scientists participating.

ORGANIZATION CHART - FY 1988

January 1988

National Marine Mammal Laboratory
Northwest and Alaska Fisheries Center
7600 Sand Point Way NE,
Seattle, WA 98115



- * temporary appointment
- ** leave without pay
- *** student
- NRC National Research Council Fellow
- NSF National Science Foundation funds

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING (RACE) DIVISION

The RACE Division continued its program of resource assessment to provide scientific information for the management of marine fish and shellfish. The Division's triennial survey emphasis was in the Bering Sea but specific purpose surveys were conducted in other areas. The Division also continued support for the second year of the west coast mesh size experiment being conducted by the Fisheries Research Institute, University of Washington, being funded by Saltonstall-Kennedy, Alaska Fisheries Science Center, and now Washington Sea Grant. In addition, research continued on recruitment processes through the Fisheries-Oceanography Coordinated Investigations (FOCI) study in Shelikof Strait, in addition to studies on fisheries pathology, ecology, acoustics, and gear performance. These activities were supported by RACE data management and gear maintenance groups.

Bering Sea Groundfish

The eastern Bering Sea supports one of the most productive groundfish fisheries in the world. Commercial catches of 1.6 million metric tons have been taken from this region each year since 1985 with an annual value to the U.S. fishing industry of more than \$1 billion.

The Bering Sea Groundfish Subtask of the RACE Division conducts annual bottom trawl surveys to monitor the abundance, distribution, and biological condition of eastern Bering Sea groundfish. The information gathered is used to provide the North Pacific Fishery Management Council (NPFMC) with fishery-independent estimates of abundance and biological condition of commercially exploited stocks, to provide distribution and abundance information to commercial fishermen, and to develop a time series data base contributing to our understanding of the population dynamics and interactions of groundfish species.

A standard sampling area encompassing about 465,000 km² and a major portion of the eastern Bering Sea shelf has been established for these annual bottom trawl surveys. Every third year, starting in 1979, the surveys are expanded beyond this standard sampling area to provide a more comprehensive assessment of eastern Bering Sea groundfish. During the expanded triennial surveys, sampling with bottom trawls is extended to the northern shelf region, including Norton Sound, and to waters of the continental slope. In addition, a hydroacoustic-midwater trawl survey is conducted to assess the midwater portion of the walleye pollock (*Theragra chalcogramma*) population

and when combined with results from the bottom trawl surveys, to provide an overall assessment of this species.

During June-September 1988, the fourth triennial survey was carried out. The bottom trawl survey involved three U.S. vessels and cooperating research vessels from Japan and the U.S.S.R. These vessels sampled about 720 stations over an area of approximately 640,000 km². A fourth U.S. vessel conducted the hydroacoustic-midwater trawl survey of pollock (see later section on Pelagic Resource Assessment).

Results of the 1988 survey showed that most of the groundfish on the eastern Bering Sea continental shelf remain in excellent condition. The abundance of walleye pollock, the major species in the complex (it accounted for about 80% of commercial catches), remains high and the population healthy consisting of larger-older fish than in earlier years. Yellowfin sole (*Limanda aspera*), the second most abundant species in the complex, has completely recovered from overfishing in the early 1960s and abundance appears to be as high if not higher than when the fishery started. Most other flatfish and Pacific cod (*Gadus macrocephalus*) are also at or near observed peak levels of abundance.

Commercially important species primarily occupying continental slope waters, such as Pacific ocean perch (*Sebastes alutus*), sablefish (*Anoplopoma fimbria*), and Greenland turbot (*Reinhardtius hippoglossoides*), have not shown the increases in abundance exhibited by many of the species on the shelf. Results of the 1988 survey, however, indicate little change from the abundance estimates derived from the previous triennial survey in 1985. Thus, management measures designed to protect these species appear to be successful.

Bering Sea Groundfish Subtask personnel, in addition to carrying out the 1988 triennial survey, also participated in the preparation of the 1988 document describing the condition of Bering Sea groundfish for use by the NPFMC in establishing catch quotas for the 1989 fishing season. They also presented results of these assessments and other studies at the annual meeting of the International North Pacific Fisheries Commission (INPFC) in Tokyo, Japan; the U.S.-Canada-Norway recruitment workshop in Bergen, Norway; and the International Pollock Symposium in Anchorage, Alaska.

Gulf of Alaska Groundfish

During 1988, personnel from the Gulf of Alaska/Aleutian Islands Subtask completed a variety of field research activities and made significant contributions to the INPFC and NPFMC through status of stocks documents and other publications and presentations.

The U.S.-Japan cooperative longline survey was once again conducted in the Aleutian Islands, the Bering Sea, and the Gulf of Alaska. The Japanese longline vessel *Tomu Maru No. 88* sampled 107 stations, setting 7,200 hooks (8.6 nmi of groundline) at each station. The depths sampled by each set ranged from approximately 100 to 1,000 m. Primary objectives included obtaining indices of sablefish and Pacific cod abundance; assessment of other major catch components such as halibut, arrowtooth flounder (*Atheresthes stomias*), Greenland turbot, rockfish, thornyheads (*Sebastolobus* spp.), and grenadiers (family Macrouridae); tagging sablefish; and collecting biological information from sablefish. As in previous years, the cruise occurred from May to September. U.S. scientists were aboard the vessel during all research operations.

The second U.S. longline survey of the upper continental slope of the Gulf of Alaska was conducted in cooperation with the Auke Bay Laboratory from 6 July to 17 September. Forty-seven stations were sampled at the same preestablished sites distributed from the Islands of Four Mountains (long. 170°W) to Dixon Entrance that have been fished annually since 1978 by the U.S.-Japan cooperative longline survey. The U.S. sampling gear was identical to that of the Japanese with respect to the number of hooks, bait, and length of each skate but differed with regard to the hook type, gangion length and thickness, and anchoring arrangement. It differed from the U.S. gear used in 1987 with regard to bait type (squid instead of herring) and heavier gangions. Once again, additional sampling was performed in gullies to assess the abundance and size composition of the sablefish in those areas. Previously, certain assumptions were made in extrapolating catch per unit efforts (CPUEs) and size compositions from the upper slope stations to deep, large gullies that were not actually sampled. The results of this survey show that extrapolated relative population numbers and size compositions may not have been appropriate. Comparisons between the CPUEs realized by the U.S. and Japanese longline gears are being made to relate the two data series.

A survey for juvenile and young-of-the-year pollock was completed by the research vessel *Alaska* from 17 August to 12 September. The survey began at Sandpoint, Alaska, and moved westward along the Alaska Peninsula to Unimak Pass. The survey then continued eastward along the outside of the Shumagin Islands to lower Shelikof Strait and up the east side of Kodiak Island. Pollock encountered along the track lines were sampled with midwater trawls while the echo traces were qualitatively evaluated to estimate both distribution and relative abundance.

West Coast Groundfish

A survey to obtain indices of sablefish relative abundance was completed off California and southern Oregon as part of long-term research initiated in 1977 to monitor changes in population size and biological composition. Strings of 10 traps each were

fished at 9 stations in depths of 275 to more than 1,370 m. Catch rates were highest at 412 and 550 m and mean lengths increased with depth. Catch rates in 1988 for the nine sites combined were 132% higher than those obtained from the 1986 survey and 8% higher than those from 1984. In 1988, catches increased mainly at the shallow depths (275, 412, and 550 m). These catches consisted almost entirely of sablefish smaller than the minimum legal length of 22 in (4 cm fork length), suggesting that the increase in catch rate is likely due to strong recruitment. These indices were instrumental in the Pacific Fishery Management Council's annual assessment of stock status and the recommendations for acceptable catches in 1989. In addition, over 6,000 sablefish were double tagged with anchor tags and released during the survey as part of a continuing study of migration, stock identification, and tag loss rates being conducted in cooperation with the Southwest Fisheries Science Center's (SWFSC) Tiburon Laboratory.

The RACE Division and SWFSC conducted a cooperative upper continental slope groundfish survey aboard the research vessel *Miller Freeman* off the west coast between Hecata Head and Cape Lookout, Oregon, in November and December 1988. The primary objectives of the survey were to examine sablefish size, sex ratio, age, and reproductive condition as a function of bathymetric distribution in the late winter; to conduct a limited area pilot study to compare area-swept (bottom trawl) and egg production estimates of sablefish abundance and spawning biomass; and to obtain extensive biological data including sex, length, weight, and maturity for Dover sole (*Microstomus pacificus*), shortspine thornyhead (*Sebastolobus alascanus*), arrowtooth flounder, and designated key rockfish species.

Trawl samples were obtained at 65 stations between depths of 180 and 1,280 m. Sablefish and Dover sole were present in all depth strata. Dover sole were most abundant in the 367-549 m stratum, while sablefish were most abundant in the 550-732 m stratum. Giant grenadier (*Albatrossia pectoralis*) and snow (Tanner) crab (*Chionoecetes bairdi*) were taken in the four deepest strata (555-732 m, 733-914 m, 915-1,097 m, and 1,098-1,280 m). Longspine and shortspine thornyheads were dominant components of the groundfish community on the upper continental slope. Other data collected included standard and deep CalCOFI oblique plankton samples, sea temperature, oxygen content and salinity, MANTA neuston samples, and SCANMAR trawl net mensuration data.

Scientists at the SWFSC will focus on studies of the maturation and biology of sablefish, Dover sole, and other key slope species, while Alaska Fisheries Science Center scientists will determine distribution, abundance, and species associations. A second survey of the area will be conducted by the NOAA research vessel *David Starr Jordan* during March-April 1989 to investigate seasonal differences in distribution, abundance, maturation, and biological characteristics of target species. That cruise will occur

during the prime spawning season, so additional plankton neuston and physical oceanography samples will be collected.

Pelagic Resource Assessment

Hydroacoustic-midwater trawl assessment of pelagic resources is the primary activity of this task. Associated activities include fisheries acoustic system development, target strength measurement, and research into the other factors influencing accuracy and precision of acoustic surveys. The task conducts annual assessments of pelagic pollock in the Gulf of Alaska, triennial assessments of pelagic pollock in the eastern Bering Sea shelf and slope regions, and triennial assessments of pelagic Pacific whiting (*Merluccius productus*) off the coasts of California, Oregon, and Washington. Since the beginning of 1988, the task has participated in surveys of pelagic pollock in the Aleutian Basin; some of these Basin surveys have been conducted in cooperation with the Far Seas Fisheries Research Laboratory of the Fisheries Agency of Japan.

Aleutian Basin Surveys

During the summer of 1988, personnel in the Pelagic Resource Assessment Task participated in a cooperative U.S.-Japan survey of the Aleutian Basin that was conducted on board the chartered Japanese fishing vessel *Seiju Maru No. 28*. An echo integration-midwater trawl survey of the basin east of the U.S.-U.S.S.R. convention line was conducted during August, September, and October. Data is currently being analyzed and preliminary results should be available by late 1989.

Eastern Bering Sea Survey

An echo integration-midwater trawl assessment of pelagic pollock in the waters of the eastern Bering Sea shelf and slope was conducted on board the chartered commercial trawler *Pelagos* during June, July, and August 1988. The demersal component of the shelf and slope stocks was also surveyed by members of the Bering Sea Groundfish Sub-task. The combined results of these surveys will constitute the fourth in a triennial series of comprehensive assessments of pollock in this region. Data processing will be completed by mid-1989. In general, it was observed that adult fish occurred in 60-100 fathom water while age 0 fish were observed in shallower (50-60 fathom) water. The densest distributions of pelagic pollock were observed in the northwestern portion of the survey area, especially to the west of St. Matthew Island.

Gulf of Alaska Survey

An echo integration-midwater trawl survey of spawning pollock was conducted in March 1988. This survey was comparable to those conducted in 1981 and from 1983 through 1986 and was designed to assess the biomass and population abundance of pelagic spawning pollock. Twenty-six midwater trawl hauls and 1,700 nautical miles (nmi) of acoustic transects were completed during the 1988 survey. The estimated biomass and population of pollock aged 2 and older was 324,800 t and 1,350 million fish, respectively.

Shellfish Assessment

Research conducted by the Shellfish Assessment Task located at the Kodiak Laboratory during 1988 included continued assessment of eastern Bering Sea crab stocks, monitoring of shrimp abundance, and biological studies of invertebrates that have established or potential commercial importance. Additionally, the general distribution and abundance of commercially harvested snails was monitored as part of on-going survey activities.

Eastern Bering Sea Crab Survey Results

With the exception of the golden king crab (*Lithodes aequispina*), which frequents un-trawlable grounds, the ranges of all commercially important crab stocks were surveyed in 1988 Bering Sea triannual survey described in the Bering Sea groundfish section. Additionally, this survey of the northern Bering Sea and Norton Sound provided abundance estimates of Norton Sound red king crab (*Paralithodes camtschatica*), continuation of recruitment relationships in Tanner crab (*C. opilio*) study, and a first-time assessment of the occurrence of "bitter crab" disease in *C. opilio*.

King crab stocks remain at low abundances relative to the history of both surveys. In Bristol Bay, estimated abundance of legal males declined to 6.4 million crab or 20% relative to 1987. This decrease was not statistically significant, but the abundance of males available for recruitment over the next 2 years declined significantly to a historic low of 6.4 million or 47% relative to 1987. Concern for the future of the fishery led the Alaska Department of Fish and Game (ADF&G) to lower the exploitation rate from 30 to 20%. The fall fishery harvested 7.4 million pounds in 1988, as compared to 12.3 million pounds in 1987. Continued declines could lead to a closure of the fishery in 1989. The Norton Sound estimate of legal males was 1.0 million crabs, as compared to 1.2 million in 1985. The 1988 fishery produced 0.2 million pounds versus the 0.3 million pounds landed in 1987. In the Pribilof Islands, legal male blue king crab (*P. platypus*) declined significantly to a record low of 0.2 million or by 73% relative to 1987.

No crab of sizes that would recruit over the next 2 years were captured in the survey. This situation led ADF&G to close the fishery in 1988 and it will almost certainly remain closed in 1989. The 1988 estimate for legal males in the St. Matthew Island area was 0.8 compared to 0.7 million in 1987. Landings increased from 1.0 million pounds in 1987 to 1.3 million in 1988. Stock conditions in the St. Matthew Island area are considered stable but low.

The condition of eastern Bering Sea Tanner crab stocks appeared to show continued improvement. Survey catch rates, however, were extremely variable and increases in estimated abundance of commercial-size crab were not statistically significant. Pre-recruit male abundance increased substantially for *C. bairdi* and was stable for *C. opilio*. The estimated abundance of legal male *C. bairdi* increased from 8.3 million crab in 1987 to 17.4 million in 1988. The spring fishery for *C. bairdi* produced 2.2 million pounds in 1988. In contrast, the *C. bairdi* fishery was closed in both 1986 and 1987 due to low stock abundance. Abundance of legal *C. bairdi* is expected to increase in 1989. The estimated abundance of commercially exploitable *C. opilio* increased to 171.0 million crab or by 13% relative to 1987. The spring fishery produced 135.3 million pounds in 1988 and a record 141.0 million pounds in 1989 (preliminary). Overall *C. opilio* stock conditions are expected to be stable in 1989.

Shrimp Research

The annual survey of Pavlof and Volcano Bays was conducted in August. The survey consisted of 22 tows. Measurements were taken from 5,100 shrimp and 80 sets of histopathological samples were collected. Average catch rates declined from 38 (1987) to 12 pounds per nautical mile in 1988. Biomass estimates were 160,000 lb in 1988 and 630,000 lb in 1987. The 1988 biomass remained far below the peak estimate of 53,170,000 lb in 1977. Pink shrimp (*Pandalus borealis*) continued to be the dominant species (94%). Shrimp were also smaller in 1988 (174 per lb) than 1987 (105 per lb). The Pavlof Bay area shows no sign of recovery. As in the past several years, finfish dominated shrimp fisheries and made up 92% of the total weight. Flathead sole, Pacific cod, and Alaska pollock together made up about 97% of the finfish catch. Results of the 1988 survey have been distributed to industry. Samples of shrimps taken in the 1988 eastern Bering Sea survey have been processed. Preliminary results do not indicate any recovery of eastern Bering Sea northern pink shrimp stocks.

Sea Urchins

The Kodiak sea urchin fishery has continued to expand. Landings were 13,900 lb in 1985, 31,700 lb in 1986, and 104,140 lb in 1987. Landed value was over \$0.69 per pound live weight in 1987. Most landings occur in the fall and 1988 landings were 190,500 lb

worth \$152,400. Research has been conducted through the development of the fishery and is now nearing completion. Knowledge of how gonad (product) recovery rates vary seasonally and with size is necessary for fishery development and management. Research has demonstrated that: 1) recovery rates are lowest in June following March-April spawning but increase steadily through summer and fall to about 20% in October and almost 29% in January; 2) roe color and firmness are best in the fall; firm, yellow-orange roe is easily extracted and most desirable in the fresh market (October-November is best), by late January it is difficult to extract any intact roe; 3) urchins reach a marketable size slightly over 50 mm diameter in about 4 years under favorable conditions but mature at 2 to 3 years; and 4) recovery rates increase significantly between 20 and 45 mm diameter. A report detailing these results is in preparation.

Underwater Research

Scientists at the Kodiak Laboratory conducted in situ research on growth and behavior of red king crab in nearby Womens Bay. Juvenile crabs form dense aggregations called pods which are shaped somewhat like haystacks and are readily observed by scuba diving. A major study of the behavioral ecology of podding crabs was conducted in 1988. The study recorded nocturnal foraging and homing behavior for the first time; it also reported that molting was observed only at night. Average pod movements were counter to prevailing currents. During nocturnal foraging, crab fed most frequently on sea stars and macrophytes. Measurements of juvenile king crabs were taken during the pod study and in the course of other diving projects. These measurements were analyzed to estimate growth rates in conjunction with temperature data collected at 12-hour intervals with a recording thermograph. Results confirmed the dependence of growth rates on integrated temperature (degree-days) that had been used in modeling growth of red king crab in the Bering Sea.

Recruitment Processes

Fisheries-Oceanography Coordinated Investigations (FOCI), a NOAA cooperative research program between the Recruitment Processes Task of the RACE Division and the Pacific Marine Environmental Laboratory (PMEL), is designed to investigate the causes of recruitment variations in commercially important fish and shellfish. The program's initial focus has been on the well-defined spawning population of walleye pollock in Shelikof Strait. The program consists of several areas of research, including field studies of eggs and larvae in relation to zooplankton and the physical environment, biochemical methods for assessing larval starvation and predation, and juvenile behavior.

During the spring of 1988, FOCI conducted four cruises. The first, in early April, investigated the abundance and the horizontal and vertical distribution of eggs. The second, in late April, intensively studied the plankton, hydrography, nutrients, and transport of early larvae; the third cruise, in early May, mapped the distribution of larvae from the Shelikof spawning. The fourth cruise, in late May, measured growth and mortality of the larvae. During the late April cruise, scientists from the Atlantic Oceanographic and Meteorological Laboratory (AOML) in Miami, Florida, joined RACE scientists to use a MOCNESS sampler to investigate the vertical distribution of pollock eggs and larvae and their zooplankton prey.

Experimental laboratory studies on pollock eggs and larvae were conducted to test new methods of determining the causes of egg/larval mortality and to calibrate existing methods. The laboratory work performed at the Manchester Laboratory and at the newly developed rearing laboratory at Sand Point in 1988 involved determining the effect of temperature and food ration on larval growth and RNA/DNA ratios and calibrating an antibody probe used to study predation by invertebrates on pollock eggs and yolk-sac larvae. Work at Sand Point also included studies of larval histological and morphological conditions as indicators of larval condition and of ageing fish larvae by counting daily growth increments on the otoliths of field-caught larvae.

Laboratory studies on walleye pollock adults, juveniles, and larvae were continued at the Newport, Oregon, facility under the direction of Bori Olla as part of FOCI. The reproductive behavior of walleye pollock was studied in an environmentally controlled 15,000 liter observation tank. While males and females typically aggregated together near the surface, males descended from the aggregation five times more frequently than did females, indicating some segregation of the sexes by depth, an observation that has also been reported on occasion from indirect field observations. Spawning typically took place when females descended from the aggregations and encountered sexually active males. Of 79 spawnings (7 females, 4 males), more than 75% of them occurred either at night or during evening or morning twilight. The number of social interactions between males or males and females was also highest during these periods, lending support to the conclusion that adults are more active by night than by day.

The same environmental observation tank was programmed to duplicate temperatures and simulate thermoclines that juvenile pollock are exposed to in the Bering Sea and the Gulf of Alaska. Preliminary studies showed juveniles avoiding crossing the thermocline, remaining in relatively warm water above a sharp thermal gradient. However, when food was available only below the gradient, fish would swim downward through the thermocline into cold water in search of food but would be much less efficient at consuming it than they were in warmer water. Further, if transient sorties into cold water lasted more than several minutes, juveniles became disoriented and were not

able to successfully return to the upper warm layer or to respond behaviorally to alarm stimuli. Field observations by Bailey have shown that when food is not available above a thermocline and juveniles venture beneath it presumably to find food, vulnerability to predation increases.

Studies to define the factors which influence vertical migration in larval walleye pollock are continuing. Progress is also being made in establishing behavioral criteria of viability in larvae in order to more sensitively measure larval condition and survivability.

An extensive project on the bioenergetics of larval pollock was conducted by a visiting scientist (Dr. Yoh Yamashita) from the Ocean Research Institute, Tokyo, Japan. He also did a study on electron transport system activity in larval pollock. Finally, a visiting researcher from the SWFC (Gail Theilacker) did preliminary experiments assessing the use of flow cytometry in measuring RNA/DNA in specific tissues of larvae.

From 1980 through 1987, 10 ichthyoplankton surveys were conducted off Washington, Oregon, and northern California coasts. Task personnel are now analyzing the results from all of these surveys to establish annual patterns of occurrence of fish eggs and larvae of the region, and how these relate to local oceanography.

A major emphasis of the Task was to increase the ability to identify fish eggs and larvae collected. A major publication summarizing these findings and entitled "A Laboratory Guide to Early Life History Stages of Northeast Pacific Fishes" is now in press. Research is being continued to establish early life history series through rearing and examination of plankton samples. Rockfishes (*Sebastes*) are a prime target of this research.

Fisheries Resource Pathology

The Fisheries Resource Pathology Task again experienced a large increase (approximately 180%) in fish and shellfish tissue collections over the previous year. Task personnel participated in the following surveys: Eastern Bering Sea crab and groundfish, Pavlov Bay shrimp, Young-of-the-year, and the West Coast Slope during which a total of 2,360 specimens were collected.

The Task entered a cooperative study with the Kodiak Laboratory (NMFS) and FRED (Fisheries Rehabilitation, Enhancement and Development) of the ADF&G-Juneau to determine the distribution and prevalence of Bitter Crab disease in *Chionoecetes opilio*. This newly discovered disease referred to as "bitter crab" was found in *C. opilio* in 1987. The disease is caused by a parasitic dinoflagellate, *Hematodinium* sp., that is fatal to in-

ected crabs. Heavily infected crabs processed for human consumption possess a bitter aftertaste but are not a public health concern. Blood smears and histological samples were taken during both Bering Sea Surveys in 1988. Preliminary results indicate that the parasite is widely distributed in opilio crabs north of St. Matthew Island in the Bering Sea where station disease prevalences range from 7% to 48%. About 38% of *C. opilio* in Norton Sound were infected. Fortunately, Norton Sound is far from commercial fishing grounds. Incidences were 5% for the northern Bering Sea, 8% on commercial grounds west of long. 173°W, and 1% east of long. 173°W. It is worth noting that the western area produced 44% of *C. opilio* landings in 1988. Further collections from both species of Tanner crabs will be taken in 1989.

The Task continued its ongoing investigations on the diseases of red and blue king crabs. Prevalences of important viral and microsporidian diseases continue to remain low since the recorded high levels of 1985. No new potentially important infectious agents have been identified.

The year 1988 represents the third and final year during which juvenile walleye pollock (n mm) were collected for disease studies. Juveniles were targeted for study because mortalities in this age group most adversely affect adult abundance. Present information indicates that a microsporidian that infects skeletal muscle may play an important role in the population dynamics of this commercially important fish species. Prevalences of this potentially fatal parasite range from 3-25%.

Foreign Cooperative Research

Thirteen foreign fisheries research vessels operated in North Pacific waters in cooperation with the Center during 1988 (Table 1). Research objectives were varied. The U.S.S.R. placed emphasis on groundfish species, and Japan dealt primarily with salmon and groundfish. U.S. investigators participated aboard three Soviet vessels and four Japanese vessels.

The Japanese continued their annual involvement in monitoring changes in the abundance and other features of Alaska groundfish. They participated in a trawl and acoustic survey in the Bering Sea using the *Seiju Maru No. 28* and in the annual longline survey of sablefish in the Gulf of Alaska, Aleutian Islands, and Bering Sea. They plan to discontinue their cooperative efforts on sablefish and other groundfish in the U.S. EEZ, since their fisheries no longer have access to these resources. However, they have said that they would cooperate with the AFSC in 1989 on pressing questions regarding the pollock that lie in the international zone (the so-called "Donut Hole" area) of the Bering Sea and adjacent waters of the Aleutian Basin and continental shelf areas with the *Tomi Maru No. 88*.

Table 1.--Scheduled U.S. Cooperative Research with Foreign Governments - 1988
Alaska Fisheries Science Center, NOAA, Seattle, WA.

Vessel	Nation	Operating area	Dates	Research program
DARWIN	USSR	B. Sea Gulf	3/16-8/1	Groundfish
GISSAR	USSR	B. Sea	May	Plankton
NEMIROV	USSR	N. Pacific	4/6 -5/20	Salmon (Seine)
TINRO	USSR	N. Pacific	4/28-5/15	Salmon (Trawl)
OSHO MARU	JAPAN	N. Pacific B. Sea	6/6 -8/18	Gill net, Longline
HOKUHO MARU	JAPAN	N. Pacific	6/6 -8/4	Gill net, Longline
IWAKI MARU	JAPAN	N. Pacific	6/1 -7/15	Gill net
KAIUN	JAPAN	N. Pacific	6/2 -7/20	Gill net
HOKKO MARU	JAPAN	N. Pacific	6/25-7/19	Gill net
WAKATAKE MARU	JAPAN	N. Pacific B. Sea	6/7 -7/28	Gill net, Longline
TOMI MARU #88	JAPAN	B. Sea N. Pacific	5/17-9/21	Sablefish, Longline
SEIJU MARU #28	JAPAN	B. Sea	7/30-10/20	Pollock
SHUNYO MARU	JAPAN	B. Sea	7/1- 8/24	Entanglement

In 1988, the Soviets provided their research vessel, *Darvin*, for a survey of young pollock in the Bering Sea and Gulf of Alaska, as well as the *Nemirov* and *Tinro* for salmon studies.

Conservation Engineering

In 1988, the Conservation Engineering Task continued its work on identifying the most important factors causing variability in the operating dimensions of survey trawls and analyzing the effects of this variability on area-swept abundance estimates.

An experiment aboard the NOAA ship *John N. Cobb* was carried out in April 1988 to quantify the effects of varying depth and wire out on trawl width and height. The expected increase in net opening width with increased wire out was the principal effect observed. During the same cruise, a new rigging of a midwater trawl used on the *Cobb* by the Auke Bay Laboratory was tested.

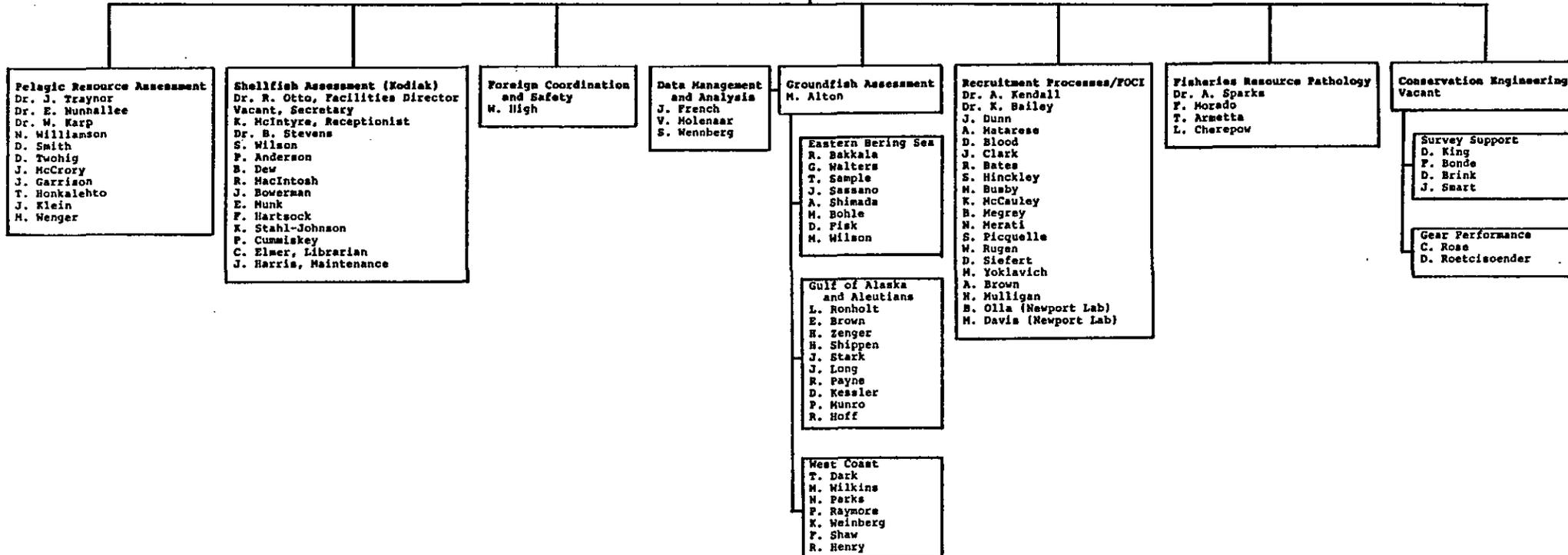
Measurements of operating width and height were made on 55% of the survey trawl hauls made during the 1988 Bering Sea survey. This allowed a comparison of the effects of different methods for estimating trawl width on survey results. Single value methods were found to cause underestimates of abundances in shallow water. Methods correcting for the effects of wire out (depth) on trawl width matched results generated with actual measurements well.

Testing and development of an electronic device for measuring and recording fish length data continued. Both lab and field tests were conducted. In lab tests, the new system significantly outperformed the older manual method in both speed and accuracy. In the field, the speed advantage was negated due to increased difficulties while handling live fish.

The Task continued its vital role of fabrication, reconstruction, and supply of survey fishing gear to a fleet of NOAA and chartered research vessels working from California to the Bering Sea. This included support of research by NMFS laboratories at Seattle, Kodiak, Auke Bay, Honolulu, Tiburon, and La Jolla, as well as support of the west coast mesh selection study and the project for reducing sea lion predation on steelhead at the Hiram M. Chittenden Locks in Seattle, Washington, in cooperation with the Northwest Region and NMML.

RESOURCE ASSESSMENT AND CONSERVATION ENGINEERING DIVISION ORGANIZATION--1988

RACE DIRECTORATE
 Dr. G. Stauffer, Director
 Vacant, Scientific Program Manager
 L. Oldham, Secretary



RESOURCE ECOLOGY AND FISHERIES MANAGEMENT (REFM) DIVISION

The REFM Division conducts research on the biology, ecology, and utilization of marine resources to assist in the management of the Northeastern Pacific Ocean and Bering Sea fisheries. Activities are organized under the foreign fisheries observer program, age and growth studies, resource ecology and ecosystems modeling, food habits studies, status of stocks, and socioeconomic tasks.

Foreign Fisheries Observer Program

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

The year 1988 was the 12th year that foreign and joint venture fisheries operated under the Magnuson Fisheries Conservation and Management Act (MFCMA). During 1988, the Program deployed 342 observers to sample aboard vessels from five countries--Japan, Republic of Korea, U.S.S.R, Poland, and the People's Republic of China. The observers spent about 14,892 cumulative days sampling in the Bering Sea, Gulf of Alaska, and waters off Washington, Oregon, and California. Observers covered 94% of the foreign and joint venture fishing effort. Coverage was 94% in the Bering Sea-Aleutian Islands region, 92% in the Gulf of Alaska, and 96% along the Washington, Oregon, and California coasts.

In 1988, the Program cooperated with the University of Alaska Fairbanks Sea Grant Program, the Alaska Department of Fish and Game (ADF&G), and the North Pacific Fishery Management Council (NPFMC) in continuing the NPFMC's pilot program of placing observers on U.S. domestic fishing vessels operating in the groundfish fishery off Alaska. The Program was responsible for defining sampling duties and data collection methods used by observers, training of observers prior to deployment, debriefing of observers upon their return, and editing and managing the resulting data. In 1988, the Program also cooperated with the fishing industry in conducting two industry-funded observer programs in selected elements of the domestic groundfish fishery off

Alaska. The Program's involvement in these endeavors was similar to that in the NPFMC's pilot study.

Age and Growth Studies

The primary responsibility of the Age and Growth Studies Task is to age samples collected from commercially important species of groundfish. This is achieved by counting the annual rings on otoliths, scales and fin-rays. The Task must also establish ageing criteria for new species and examine problem areas where the generated ages appear unsatisfactory. Data from the Age and Growth Task are used by stock assessment scientists to model fish population dynamics. These results are in turn used by fishery management agencies. In 1988, otoliths were used to age over 20,000 walleye pollock (*Theragra chalcogramma*), Pacific whiting (*Merluccius productus*), Atka mackerel (*Pleurogrammus monopterygius*), sablefish, yellowfin sole (*Limanda aspera*), rock sole (*Lepidopsetta bilineata*), Pacific ocean perch, and northern rockfish (*Sebastes polyspinis*). As a quality control measure, 20% of all production readings were aged independently by a second highly experienced age reader.

Resource Ecology and Ecosystems Modeling Task

A study of length (age) composition of catches and fluctuations of recruitment of Pacific cod, walleye pollock, and yellowfin sole from the eastern Bering Sea from 1978 to 1987 was carried out. The recruitment fluctuations from year to year of these three species were very small indeed, indicating that recruitment is largely controlled by density dependent predation. Some apparent year class strength fluctuations were caused by changes in fishing patterns. Furthermore, the age composition of catches indicate that the exploitation rate is slight on all three species. A separate study on the effect of fishing on age composition of catches was also completed.

Numerical studies of the eastern Bering Sea's carrying capacity were completed, showing that the main determinants of this capacity are zooplankton production and the species composition of the fish ecosystem.

Studies of long-term changes of surface meteorological parameters showed a steady increase of surface wind speed at lower latitudes ((oN) from 1960 to 1967 (about 1 m/sec) resulting in increased precipitation in these areas. Causes and other consequences of these changes are being investigated.

A multispecies virtual population analysis (VPA) adapted by this Task to include spatial variability in fishing pressure and species distributions was set up as a first step in investigating interactions between the Bering Sea groundfish and crab complexes. This

project entails considerable involvement of members of this task and of REFM in general. As a precursor to this work, virtual population analyses of red king crab and the two snow (Tanner) crab species (*Chionoecetes opilio* and *C. bairdi*) were developed for the Bering Sea. A second adaptation of VPA including cannibalism and predation by marine mammals in a single species VPA of Bering Sea pollock was concluded. This work provides an alternative to the present assumption of constant natural mortality in VPA.

Cooperative research on multispecies analyses and ecosystem concepts with outside agencies continued in 1988. This Task worked with the Norwegian School of Fisheries, University of Tromsø in Norway in July and August, where multispecies analyses of Balsfjorden, a north Norwegian fjord, were designed with the cooperation of members of this Task. Collation of fisheries survey and catch data was undertaken to provide a history of the fjord with which to tune the dynamic part of the model. The results from this work will be used in planning future enhancement and exploitation of Balsfjorden. Methodology developed in this cooperative research, in particular the modeling of density dependent growth and prey availability, will be applied to ongoing work in the North Pacific.

This Task also cooperated with the Institute of Marine Research in Bergen, Norway, to develop a transparent multispecies analysis that could be used to provide an overview of species interactions in an ecosystem. A system of 15 linked spreadsheets was developed that enables the researcher to input estimated abundances of different fish stocks and to then evaluate their plausibility given the species interactions defined through predation. This technique will be tested by comparing two very different periods in the Norwegian and Barents Seas; it will then be applied to the North Pacific.

OSCURS (Ocean Surface Current Simulations) Model development, verification, tuning, and applications research continued. With this model, the effects of climate variations on ocean currents in the North Pacific Ocean and Bering Sea may be investigated and indexed on a daily basis from 1946 to 1987 giving us the expanded potential of a new tool for assessing interannual variability on the time scale of our choice for application to fisheries research.

The OSCURS model was tuned to match satellite-tracked drifter data from 1978 for the Gulf of Alaska. Its use is to hindcast Lagrangian drift of pelagic objects in the ocean surface mixed layer (fish eggs, larvae, and debris) with daily time steps for any desired period of history from 1946 to 1987.

It has been known for a long time that fishing debris from the western Pacific Ocean is deposited randomly on the Washington-Oregon coast. Early results from model runs

indicate that this eastward drift along lat. 50°N takes about 8 months from the Kodiak Island area; but according to the OSCURS model, there are extreme years when such debris would likely miss the coasts completely, being caught in the northward or the southward branches of the Great Divergence.

Food Habits Studies

The Fish Food Habits Program continued regular monthly observer training for collection of food habits information on key fish predators in the North Pacific. In 1988, 79 observers collected food habits data. In addition, program personnel collected fish stomach samples during the summer resource assessment survey. Over 6,800 stomachs were collected, 4,400 stomachs were scanned at sea, and 6,500 were analyzed in the laboratory. Improvements in laboratory processing of samples are being undertaken. More predator species are being subjected to quantitative laboratory scanning of contents. This allows more stomachs to be processed without sacrificing detailed information on the consumption of commercially important prey items.

Assistance and training in food habits collection and analysis methods were furnished to other Center personnel. Food habits information was analyzed, and parameters derived for two population models: a VPA model including cannibalism of walleye pollock and an eastern Bering Sea crab and groundfish interaction model. Food habits information was analyzed and provided to many different sources, including the NPFMC, the Universities of Washington and Alaska, researchers in foreign countries, and a variety of other constituents.

Several projects were completed this year regarding diet and daily ration of Greenland turbot; diet of Pacific cod; food habits and diet overlap of noncommercial eastern Bering Sea fish species; morphological differences between two flounder species (*Atheresthes* spp.); interannual trends in walleye pollock cannibalism; and interannual trends in crab consumption by Pacific cod. Research indicated that predators may cause density-dependent mortality in some prey populations, particularly in juvenile prey. Results also highlighted the importance of obtaining good geographic coverage of predator food habits samples in order to properly assess predator-prey overlap. Research emphasis was on interannual changes in predation that might provide insight into changes in year class strength or geographic distribution.

Status of Stocks Task

Alaska Fisheries

In 1988, the Status of Stocks Task continued to be actively involved in determining the condition of fisheries resources within the EEZ and developing strategies for their management. Groundfish research was conducted in cooperation with the ABL and the RACE Division on commercially important stocks in the Bering Sea, Aleutian Islands, and Gulf of Alaska regions. This research included analysis of population dynamics, evaluation of management strategies, estimation of potential yields, and development of new assessment techniques. Three Task members served on groundfish management teams for the NPFMC, providing management recommendations for a number of important stocks. Task members continued studies of walleye pollock, yellowfin sole, Pacific cod, sablefish, Pacific whiting, and Pacific ocean perch; interregional productivity of Pacific ocean perch; analysis of voluntarily submitted joint venture logbook data; and the early life history of Pacific herring in the eastern Bering Sea.

The Task continued with the second year of a 3-year initiative to better understand the consequences of the intense unregulated fishery for walleye pollock in the international zone of the Bering Sea. Thus far, the literature has been reviewed, hypotheses concerning the stock structure of the Bering Sea walleye pollock population have been developed, and the testing of the hypotheses has begun. The testing, a collaborative effort with the Center's RACE and NWFSC's CZES Divisions, focused on genetic, morphometric, and meristic features, and the otolith composition of samples taken in various parts of the Bering Sea. The second objective of the initiative was to estimate the biomass of the walleye pollock population in the Aleutian Basin, the deep water portion of the Bering Sea. Several international cooperative acoustic-trawl surveys were conducted in the basin during the spawning season. The third goal of the research was to determine the size and species composition of catches in the international zone. To achieve this, catch statistics have been requested from the various nations that fish in the zone. A voluntary observer program has also been implemented.

Studies concerning king and Tanner crab provided information used by management authorities in a variety of ways. Assessment information was employed by the Alaska Department of Fish and Game (ADF&G) for establishing quotas for the Bering Sea crab fisheries. An analysis of the Bering Sea Tanner crab fishery was used by ADF&G to make decisions regarding the timing of fishery closures. Finally, results of crab by-catch studies were considered by the NPFMC in the management of by-catch in the Bering Sea trawl fisheries.

Pacific Coast Fisheries

The Pacific Coast groundfish group has a major role in estimating the productivity of groundfish stocks managed by the Pacific Fishery Management Council. In particular, the group prepared annual status of stock reports for Pacific whiting and sablefish. The group was headed by a new leader who also served on the Council's Groundfish Management Team.

Research on the population dynamics of Pacific whiting continued to estimate the productivity of this important resource. Trends in the body growth of whiting were quantitatively described. A detailed analysis of the by-catch of other groundfish species was conducted in an analysis of a proposed management action. A description of the geographic pattern of the fishery and the resource was initiated, in collaboration with Canadian stock assessment scientists, as a first step in an analysis of optimum split of the available yield between the United States and Canada.

A comprehensive stock assessment of sablefish was conducted in collaboration with the Southwest Fisheries Science Center. The assessment used a newly developed stock synthesis model to integrate a wide diversity of fishery and survey information into a coherent description of the history and current status of this resource. Work on a generalized version of the model was initiated so that its utility can be explored for other species.

Socioeconomic Task

The Socioeconomic Task was actively involved in providing economic information to the Pacific and North Pacific Fishery Management Councils, industry, NMFS, and other agencies. This included preparing reports and publications, participating on Council plan teams, preparing and reviewing research proposals and programs, preparing analyses of proposed management measures, and providing extracts from databases. Many of these were cooperative activities conducted with economists at other NMFS sites, the regional fishery management councils, Oregon State University, Washington State University, the University of Alaska, and the University of Idaho.

The reports and publications presented the results of research concerning the development of bioeconomic models for pollock in the Gulf of Alaska and red king crab in the Bering Sea; economic and biological developments in a variety of fisheries; fishery product exports from the Pacific Northwest and Alaska; catch and revenue characteristics of vessels harvesting sablefish off the Pacific Coast; the economics of by-catch, price models, and market analysis for sablefish and Pacific halibut; the economic implications of the by-catch of salmon in groundfish fisheries; the interdependence of inter-

national trade and fishery management issues for the Alaska groundfish fisheries; the economics of mesh size regulations for the Pacific Coast groundfish trawl fishery, the empirical implications of specific dual model assumptions; and the use of new time series methods of analysis.

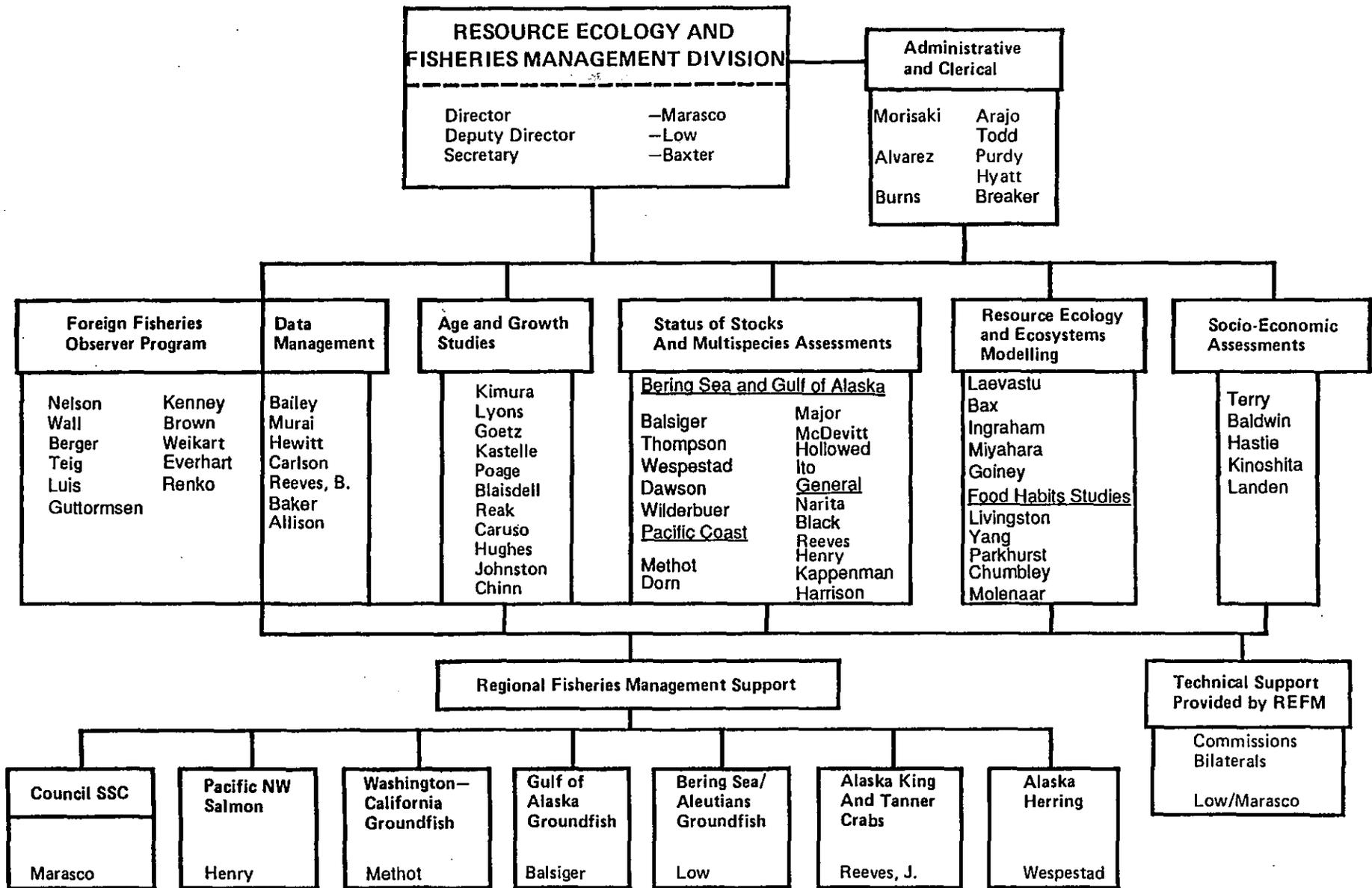
Task members reviewed Sea Grant and Saltonstall-Kennedy proposals, contributed to the development of a cooperative Pacific Coast sablefish research program, and assisted the International Pacific Halibut Commission in developing an economic research program and reviewing results of economic research it funded.

Task members contributed significantly in the preparation of economic analyses for the Bering Sea-Aleutian Islands king (*Paralithodes* spp. and *Lithodes aequispina*) and Tanner crab fishery management plan and Gulf of Alaska and Bering Sea-Aleutian Islands groundfish fishery management plan amendments.

Task members provided data base extracts for a variety of research projects conducted by others. These ranged from quick summaries of U.S. import and export data for the industry to extensive data extraction projects. The latter included providing data for the NMFS marine debris program, NPFMC economists who were analyzing management measures concerning by-catch and controlled access, and the U.S. Department of Interior Mineral Management Service.

Resource Management Advisory Functions

The Division continued to serve as a useful link between the Center's research activities and the fisheries management process. Two scientists served as NPFMC Scientific Statistical Committee members or alternates and several others served as team leaders or played key roles in the development of fishery management plans and regulations governing groundfish, herring, crabs, and salmon fisheries. The Division also organized and conducted bilateral meetings with several foreign nations to coordinate joint research and exchange data and views on the condition of stocks and their management. In addition, Division members provided scientific input to the Pacific and North Pacific Fishery Management Councils, the International North Pacific Fisheries Commission, the International Pacific Halibut Commission, and the U.S.-Canada Salmon Commission.



SPECIAL ITEMS CONCERNING NWAFFSC STAFF

Awards and Honors

Dr. Nic Bax received a Norwegian Senior Scientist Research Fellowship for cooperative work with the Norwegian School of Fisheries.

Dr. Jerry Babbitt, Director of the Utilization Research Division's Kodiak Field Station, Kodiak, Alaska, was honored by the Kodiak Chamber of Commerce when they awarded him the Chamber's "Cornerstone" Award for Service to the Community. Dr. Babbitt was specifically recognized for his outstanding contributions to the development of shore-based surimi processing in Kodiak.

Dr. Usha Varanasi, EC Division Director, received an Award for Unusually Outstanding Performance from the U.S. Department of Commerce.

Individuals Receiving Advanced Degrees

Patricia Livingston received a master's degree in Public Administration (M.P.A.) with emphasis on natural resources policy and administration from the University of Washington.

Steven Hare completed requirements for the degree of Master of Marine Affairs at the University of Washington.

Tracy K. Collier, Research Chemist, presented his doctoral dissertation and was awarded the degree of Ph.D. in Fisheries Biology by the University of Washington in June.

Rebecca Hoff completed the requirements for the degree of Master of Science from the University of Washington. Her research focused on the spatial distribution and abundance trends of two flatfish species from the eastern Bering Sea.

Richard Bakkala was awarded a Ph.D degree from Hokkaido University. His thesis is titled "Structure and historical changes in the groundfish complex of the eastern Bering Sea."

Steven Ignell and Molly Sturdevant received Master of Science in Fisheries degrees from the University of Alaska-Fairbanks.

**NWAFSC Staff Detailed to Other Laboratories
or Personnel from Other Laboratories Detailed to NWAFSC**

Mike Sigler and Ellen Varosi served on a detail to the Alaska Region's Fisheries Management Division for 3 months each to fill in for Janet Smoker who was on extended leave to Japan.

Dr. Tony Gharrett continued at ABL as the leader of the genetic stock identification studies for the U.S.-Canada Salmon Interception Program. This assignment was arranged through an Intergovernmental Personnel Act (IPA) between the University of Alaska Southeast, Juneau, and the Auke Bay Laboratory.

Dr. Kazuyuki Teshima from the Fisheries Agency of Japan's Far Seas Fisheries Research Laboratory in Shimizu completed several months of research as a visiting scientist in March. While at the Center, Dr. Teshima worked on Aleutian Islands groundfish research and participated in the spring hydroacoustic/midwater trawl survey for pollock in the Gulf of Alaska. Dr. Kei-ichi Mito, also from the same laboratory, replaced Dr. Teshima and participated in the preparation of several papers relating to groundfish research in the Gulf of Alaska.

Dr. Torbjorn Asgard from the Institute of Aquaculture Research, Sunndalsora, Norway, began a 1-year-in-residence at the Center in August 1988. Dr. Asgard is working in the area of fish nutrition in the Utilization Research Division.

Transitions

On 1 April 1988, John Spinelli retired as Director for the Utilization Research Division. Spinelli was appointed after Dr. Maynard Steinberg's retirement in 1979. His career with the agency began in 1962 when he was employed to work on the seafood product irradiation project. Dr. Mel W. Eklund was appointed Director, Utilization Research Division, in July 1988.

Dr. Wesley Ebel retired as Director of the Coastal Zone and Estuarine Studies Division in June 1988, and Gerald Monan was appointed the new Director in July 1988.

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