APPENDIX A. NMFS Scientific Enterprise

The National Marine Fisheries Service is the NOAA line office responsible for the stewardship of the Nation's living marine resources. NMFS has five regional Science Centers, composed of about 30 laboratory facilities nationwide and over 1,500 scientific and support personnel, which conduct a comprehensive, interdisciplinary science program. The scope of their work is broad in time, space, and discipline. These Science Centers provide the scientific knowledgebase on which NMFS formulates stewardship policies through to its five Regional Offices. Research at NMFS laboratories supports resource managers in NOAA, fiishery management councils, interstate fishery commissions, and other agencies in making informed marine resource management decisions for sustainable fisheries, protected resources, endangered species, and habitat.

Because fisheries are managed on a regional basis, the focus of NMFS research programs varies among the regional Science Centers. Each Science Center Director and his/her Division Chiefs develop annual research priorities, based upon regional and national needs, through dialogue with his/her Regional Administrator, councils, the Program Offices in NMFS headquarters, and with user groups and other interested parties. Within each Science Center, teams of researchers work together to develop research plans.

NMFS' longer-term integrated research program is coordinated by headquarters' Office of Science and Technology. The Science Board, composed of the five Science Center Directors and the Director of the Office of Science and Technology, is responsible for ensuring the integrity and quality of scientific research. The NMFS Science Board addresses national science issues and programs and develops science policy for the agency. All components of the science enterprise function to provide the agency with information that is comprehensive, objective, credible, and effectively communicated.

The NMFS science program has extensive collaborations with academia, many through cooperative agreements and grants. These partnerships enhance and extend NMFS' research capability. Many NMFS scientists serve as adjunct professors at nearby universities. This relationship offers intellectual stimulation and challenges for agency scientists to remain on the cutting edge, while expanding the teaching capability of the university and bringing NMFS expertise into the academic community. Academic scientists also play an important role in the periodic review and evaluation of the quality and relevance of NMFS research programs. The Science Centers work in cooperation with other Federal and state agencies, international entities, non-governmental organizations, and the private sector, including the fishing industry.

The scale and scope of NMFS research varies. Some major research initiatives focus on the needs of the fishing industry and are performed jointly with industry. For instance, joint studies of harvesting methods and development of more effective fishing gear are underway to reduce wasteful bycatch. Other research initia-

tives focus on needs of the FMCs and NMFS Habitat Conservation field offices to meet their scientific and management mandates under the EFH provisions of the MSFCMA.

Goals of the Scientific Enterprise

The mission of NMFS scientific enterprise is to ensure that the science products produced and disseminated by the National Marine Fisheries Service is of the highest quality. During the next five years NMFS will accomplish this by meeting the following goals and objectives:

Improve Scientific Capability

- Implement NRC recommendations (NRC, 1998) to ensure state-of-the-art resource assessments through our National Stock Assessment Improvement Plan (NMFS, In press). (Ongoing)

- Continue to incorporate economic and social factors into our decision-making. As part of this continuing effort, NMFS will publish the next edition of the *Our Living Oceans: The Economic Status of U.S. Fisheries*. The report will measure the economic health of U.S. fisheries relative to current conditions versus desired future conditions of long-term sustainability. (FY 2002)

- Increase our ability to predict natural living marine resource variation through improved data collection, improved understanding of how LMRs respond to environmental variability and climate change, and coordinated bio-socio-economic modeling, which will result in more accurate assessments and estimations of the uncertainty associated with them. (Ongoing)

- Increase our ability to identify, conserve, protect, and restore those habitats essential to managed fishery resources and to estimate the impact of pollution, wetland and estuarine degradation, and fishing gear on the abundance and availability of fish. (Ongoing)

Increase Science Quality Assurance

- Implement policies to ensure that our science programs, analyses, and products are sound, credible, and provide an objective basis for management. (Ongoing)

- Improve our professional standards for research and scientific advice by establishing national guidelines for technical program and staff performance evaluations, performance award programs, and professional career development opportunities. (Ongoing)

- Expand and improve our system for peer review of scientific advice by

establishing panels of knowledgeable scientists from both within and outside government. (Ongoing)

- Solicit input from external scientists in topical areas when identifying research initiatives for the various NMFS grant programs. (Ongoing)

Improve Fishery Research Capability

- Implement our fishery research vessel replacement plan (NMFS, 1998c) that integrates government, university, and industry vessel capabilities to provide the state-of-the-art facilities necessary for the accomplishment of our varied at-sea research programs. (FY 2008)

Improve Data Collection

- Implement NRC recommendations (NRC, 2000) to improve our data collection and analysis techniques and fishery data management systems. (Ongoing)

- Provide a core fishery statistics program based on our strategic and operational needs. (Ongoing)

Increase Outreach/Information Dissemination

- Involve constituents in research programs. To the extent practicable, NMFS will charter fishing vessels to participate in research projects, invite constituents to participate aboard NOAA research vessels during resource surveys, encourage frequent contact and cooperation between scientists and constituents, and develop methods to incorporate scientifically valid observations by fishers and others into fish stock assessments and other analyses related to living marine resources and their habitat. (Ongoing)

- Coordinate with the NMFS Constituent Affairs and Outreach Team to develop an Internet Web-centralized resource for neutral science-based information to educate the public and user groups and answer questions on various topics on the status of our nation's fisheries, including how NMFS research is conducted and how stock assessments are performed. (Ongoing)

- Develop a new series of reports and presentations to communicate scientific results in simplified language that is easier to understand than traditional scientific publications. (Ongoing)

Support International Fishery Science

- Participate in international scientific initiatives, such as the United Nations Intergovernmental Panel on Climate Change (IPCC), Program for the Conservation of Arctic Flora and Fauna (CAFF), Commission for the

Conservation of Antarctic Marine Living Resources (CCAMLR), Food and Agriculture Organization of the UN (FAO), Global Oceans Observing Program (GOOS), North Pacific Marine Science Organization (PICES), International Council for the Exploration of the Seas (ICES), International Whaling Commission (IWC), United Nations Atlas of the Oceans, and Global Ocean Ecosystems Dynamics (GLOBEC). (Ongoing)

- Participate in bilateral scientific initiatives with neighboring countries, Canada and Mexico, and in scientific exchange programs with foreign countries which are developing their fishery resources. (Ongoing)

NMFS Fisheries Science Centers

The National Marine Fisheries Service is a world leader in fisheries research. Each year the agency uses harvest and survey data to assess the status and trends of more than 200 major commercially-valuable fish and shellfish stocks. The NMFS Science Centers provide annual stock assessment information and management advice to support the NOAA stewardship mission for the living marine resources in their regions. These cross-disciplinary efforts are undertaken in cooperation with other Federal and state agencies, international organizations, the fishing industry, and academia, and are based on long-standing cooperative research agreements. In addition to these basic responsibilities, each regional Science Center has unique capabilities to focus on special research needs. The following is an overview of each of the five NMFS Science Centers.

Alaska Fisheries Science Center (AFSC)

Alaska Fisheries Science Center, NOAA Western Regional Campus, Seattle, Washington.

The Alaska Fisheries Science Center (AFSC) has research facilities in Alaska (Auke Bay and Kodiak Island), Washington (Seattle), and Oregon (Newport). Organizationally, the AFSC consists of the Auke Bay Laboratory (ABL), the National Marine Mammal Laboratory (NMML), the Resource Assessment and Conservation Engineering Division (RACE), the Resource Ecology and Fisheries Management Division (REFM), and other administrative units. The major survey platforms supporting the AFSC include the NOAA fishery research vessels *Miller Freeman* and *John N. Cobb*, and chartered vessels from the industry. External cooperators include state and other Federal agencies, academic institutions, foreign research institutions, the fishing industry, and resource conservation organizations.

The Center has a permanent staff of about 325 employees who conduct fisheries and marine mammal research in the coastal and offshore waters off Alaska and the U.S. west coast. This marine region of nearly three million square miles includes over 50% of the U.S. coastline and over 70% of the U.S. continental shelf. The region supports some of the most important commercial fisheries in the world, particularly groundfish and Pacific salmon species. It is host to some of the world's largest populations of marine mammals and seabirds.

The Center conducts research on the following fishery resources that are under active management:

- The groundfish fishery in the Bering Sea-Aleutian Islands region involving 14 major species and 20 minor ones including walleye pollock, Pacific cod, Atka mackerel, sablefish, yellowfin sole and other flatfish species, Pacific ocean perch, and other rockfish species.

- The groundfish fishery in the Gulf of Alaska region involving 14 major species and 37 minor ones including walleye pollock, Pacific cod, sablefish, flatfish species, Pacific ocean perch, and a variety of slope and shelf rockfish species.

- The king, tanner, and snow (*C. opilio*) crab fisheries in the Bering Sea-Aleutian Islands region.

- The Pacific halibut fishery of Canada and the U.S.

- The scallop fishery off Alaska.

- The salmon fisheries off Alaska.

In addition to fishery research, the NMML conducts research on marine mammals to determine their status, conservation needs, and potential impacts of fishing activities on the populations. The Alaska region has 37 stocks of more than 25 species of marine mammals that may be grouped as:

- Seals, sea lions, and walruses that include bearded seal, harbor seal, northern fur seal, ribbon seal, ringed seal, and northern sea lion.

- Whales, dolphins, and porpoises that include beaked whale, beluga whale, bowhead whale, Cuvier's beaked whale, fin whale, gray whale, humpback whale, killer whale, minke whale, northern right whale, sperm whale, Pacific white sided dolphin, Dall's porpoise, and harbor porpoise.

Recent Accomplishments and Research Priorities for FY 2001-2006

I. Research to support fishery conservation and management

Recent Accomplishments:

Major research cruises conducted by the AFSC included: (1) a winter hydroacoustic survey by the NOAA R/V *Miller Freeman* that estimated the biomass and distribution of pollock in Steller sea lion critical habitat on the Bering Sea shelf and in the Bogoslof area; (2) a spring hydroacoustic survey by the NOAA R/V *Miller Freeman* to determine the distribution and biomass of spawning pollock within

Research scientist monitors survey trackline during an acoustic/trawl survey of pollock aboard the NOAA R/V *Miller Freeman* in the Gulf of Alaska.

the Shelikof Strait area of the Gulf of Alaska; (3) a summer longline charter vessel survey to assess the distribution and abundance of sablefish, rockfish, and other commercially important groundfish resources in the Gulf of Alaska; (4) a summer bottom trawl survey of Aleutian Islands groundfish with two chartered fishing vessels to estimate the biomass and distribution of groundfish and to collect other biological data; (5) a summer hydroacoustic survey by the NOAA R/V *Miller Freeman* to determine the distribution and biomass of pollock on the Bering Sea shelf; (6) a summer bottom trawl survey of eastern Bering Sea shelf with two chartered fishing vessels to estimate distribution and abundance of crab and groundfish stocks, (7) a summer bottom trawl survey of Bering Sea continental slope groundfish and crab with a chartered fishing vessel; and (8) a fall bottom trawl survey of the west coast continental slope by the NOAA R/V *Miller Freeman* to determine distribution of groundfish.

The AFSC runs an ongoing Fisheries Observer Program to collect data from the fishing industry. The data include the incidental takes of all protected marine species such as marine mammals, seabirds, and prohibited species of groundfish. The data collected by these observers were used for stock assessments and real time management of the fisheries.

Sorting a catch of groundfish collected with a bottom trawl during a research cruise aboard the NOAA R/V *Miller Freeman* in the eastern Bering Sea.

The AFSC had the lead responsibility for analyzing the population dynamics and status of most of the groundfish species managed by FMPs in the Bering Sea-Aleutians and the Gulf of Alaska regions. The Center also provided analysis of the Pacific hake resource off the Pacific Coast.

The AFSC, in cooperation with the Pacific Marine Environmental Laboratory (PMEL), conducted some Fisheries Oceanography Coordinated Investigations (FOCI) as part of GLOBEC and the Southeast Bering Sea Carrying Capacity programs. These studies examine the environment and biological factors affecting the recruitment of pollock in the Gulf of Alaska and Bering Sea. Forecasts of future year class recruitment strength are made for pollock stocks and in predicting future stock levels.

The AFSC conducted studies on salmon ocean ecology, species life histories, and historical data patterns to increase understanding of how marine and anadromous species are affected by natural and human activities.

The AFSC conducted restoration studies related to the *Exxon Valdez* oil spill in Prince William Sound.

The NMML conducted research to determine the status, conservation needs, and potential impacts of fishing activities on marine mammal populations. The NMML worked closely with the Alaska Scientific Review Group (ASRG) concerning recommendations regarding the status of marine mammal stocks in Alaska. The ASRG had representatives from industry, the tribal community, and the environmental community.

The AFSC (ABL) completed a three year radio-tagging study on Yukon River fall chum salmon that documented spawning location, migration rates, and estimated numbers crossing the border into Canada. This laboratory also developed a ge-

netic baseline information base on salmonids to identify stocks or country of origin. AFSC scientists have been key partners in Coastal Fish Habitat Restoration design and application of new aquatic habitat restoration technology and in developing the database needed to test the effectiveness of those restoration designs.

Research Priorities, FY 2001-2006:

I.A. Biological research concerning the abundance and life history parameters of fish stocks

The following surveys are planned by the AFSC:

- Conduct an annual summer bottom trawl survey on groundfish and crabs in the eastern Bering Sea shelf with chartered fishing vessels.
- Conduct midwater trawl-acoustic surveys to assess off-bottom component of pollock stock in the Bering Sea every two years (2002, 2004, 2006) and the Gulf of Alaska (2003, 2005) with the NOAA R/V *Miller Freeman*.
- Conduct an Eastern Bering Sea slope survey on groundfish every two years (2002, 2004, 2006) with a chartered fishing vessel.
- Conduct an annual March survey on spawning pollock resources in the Bogoslof Island area by the NOAA R/V *Miller Freeman* or with cooperating foreign research vessels.
- Conduct an annual spring survey of pollock resources in the Shelikof area by the NOAA R/V *Miller Freeman*.
- Conduct a summer bottom trawl survey on groundfish in the Gulf of Alaska with chartered fishing vessels every two years (2001, 2003, 2005).
- Conduct a summer bottom trawl survey on groundfish in the Aleutian Islands region with chartered fishing vessels every two years (2002, 2004, 2006).
- Conduct an annual summer longline survey on sablefish resources in the Gulf of Alaska by a chartered vessel.
- Conduct a triennial summer bottom trawl survey on shelf groundfish off the Pacific West coast with two chartered vessels in 2001.
- Conduct an autumn bottom trawl survey on slope groundfish off the Pacific west coast with the NOAA R/V *Miller Freeman* in 2001.
- Conduct a triennial summer hydroacoustic-bottom trawl survey on Pacific whiting off the Pacific west coast with the NOAA R/V *Miller Freeman* in 2001.
- Conduct an annual April FOCI egg-larvae survey in the Gulf of Alaska and a May survey on late-larvae by the NOAA R/V *Miller Freeman*.

Deployment of a specially-developed acoustic buoy from the NOAA R/V *Miller Freeman*. This free-floating buoy contains a scientific acoustic system which can be used to assess local abundance of pelagic fish and observe reactions of fish to disturbance.

In addition to the above surveys, the AFSC is also planning to conduct many field operations to study marine mammal-fish interactions, with particular emphasis on sea lion-pollock/cod/atka mackerel interactions in the Gulf of Alaska to the Bering Sea areas.

The following observer programs are planned for the groundfish fisheries that occur off Alaska:

- 100% observer coverage of fishing and processing vessels longer than 125 feet.
- 100% observers coverage of most fish processing plants onshore.
- 30% observer coverage of fishing vessels that are 65-125 feet.
- 100% observer coverage (with multiple observers) of special category vessels that engage in community development quota (CDQ) and American Fisheries Act (AFA) fishing operations.

The AFSC will assess the status of stocks, estimate their biological production potentials (MSY, acceptable biological catch (ABC), overfishing levels), bycatch requirements, and other parameters required for their management. The following stocks will be assessed annually and be published in stock analysis and fishery evaluation (SAFE) reports:

- All Bering Sea-Aleutians and Gulf of Alaska groundfish stocks, including pollock, cod, sablefish, atka mackerel, yellowfin sole, rock sole, flathead sole, Greenland turbot, other flatfish, Pacific ocean perch, and other rockfish species.
- King and tanner crabs in the Bering Sea.

Steller sea lion, Middleton Island, Gulf of Alaska.

The NMML will assess the population dynamics, ecosystem interactions, and abundance of marine mammal stocks and their incidental take requirements. Some specific programs and activities that will be pursued are:

- Implement the Steller Sea Lion Recovery Plan.
- Implement the Steller Sea Lion — Fishery Interactions Research Plan.
- Implement the Northern Fur Seal Conservation Plan.
- Implement the Alaska Harbor Seal Research Plan.
- Analyze existing aerial survey data and harvest monitoring data on Alaskan ice seals.
- Analyze data collected during the international Antarctic Pack Ice Seal (APIS) cruise.
- Implement the Humpback Whale Recovery Plan.
- Implement the Northern Right Whale Recovery Plan as it pertains to the North Pacific.
- Implement an extended five-year research and monitoring plan for the eastern North Pacific gray whale.
- Analyze data collected during the 1997-1999 small cetacean surveys in Alaska.
- Implement the west coast pinniped-salmonid research plan.
- Monitor the Makah gray whale harvest.

NMFS scientist investigates dietary components of Steller sea lions and other marine mammals in Alaska.

I.B. Social and economic factors affecting abundance levels

- Expand sociological and economic research and incorporate results into the fishery management process.

- Conduct research on vessel over-capitalization and impacts of their fishing effort levels on fisheries.

- Compile and analyze data on harvesting and processing sector behavior.

I.C. Interdependence of fisheries or stocks of fish

- Collect biological specimens of spawning pollock throughout its range for genetic marker studies through DNA and other genetic techniques. Cooperation with foreign scientists is required for sampling non-U.S. waters.

- Analyze survey and observer data to determine spatial distributions of different species clusters that would indicate separation or interdependence of stocks.

- Develop genetic baseline information on salmonids to identify stocks or area of origin.

- Conduct winter surveys to estimate distribution and abundance of pollock (acoustic) and Pacific cod (bottom trawl) in Steller sea lion critical habitat areas in southeast Bering Sea, Shumagin Islands, and Kodiak Island to determine dependence of sea lions on localized food supplies and assess feasibility of annual time series.

I.D. Identifying, restoring, and mapping of essential fish habitat (EFH)

- Conduct studies on the impacts of logging, urbanization, and mining on coastal salmon resources in southeast Alaska. NMFS will work with the Corps of Engineers and local organizations to restore an urban impacted salmon stream.

- Conduct restoration studies related to the *Exxon Valdez* oil spill in Prince William Sound. The research will build upon the results reported in the accomplishments section, including a study of the effects of oil on the biology, homing, and survival of pink salmon.

I.E. Impact of anthropogenic factors and environmental changes on fish populations

- Investigate mortality and pathogens of shellfish and groundfish.

- Conduct Fisheries Oceanography Coordinated Investigations (FOCI): a cooperative research program with the Pacific Marine Environmental Laboratory of NOAA's Oceanic and Atmospheric Research Office to investigate the causes of variation in annual recruitment in fish stocks.

- Assess effects of fishing on EFH and develop ways to minimize adverse impacts.

II. Conservation engineering research

Recent Accomplishments:

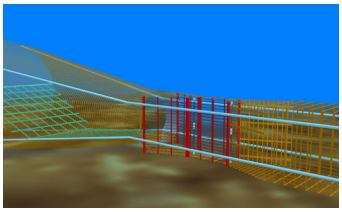
The AFSC conducted research to measure the direct effects of bottom trawling on seafloor habitat in eastern and central Gulf of Alaska, eastern Bering Sea, and the Aleutian Islands. Some of the major accomplishments were: (1) the assessment of changes to the seafloor caused by chronic long-term trawling in soft-bottom areas in the Gulf of Alaska; (2) the examination of possible adverse effects of bottom trawls on soft-bottom benthos in the eastern Bering Sea; (3) the evaluation of acoustic technology for seabed classification; (4) the assessment of impacts to habitat areas of particular concern (HAPC) such as gorgonian corals; (5) the documentation of the effects of trawling on hard bottom habitat in the Aleutian Islands and Gulf of Alaska; and (6) the mapping of the areas by sediment types.

The AFSC worked cooperatively with the industry's Groundfish Forum by chartering two fishing vessels to test a flexible grate system in bottom trawls designed to reduce the bycatch of Pacific halibut in trawl fisheries for Pacific cod. Preliminary results are very promising that this technology will be successful in reducing bycatch of halibut. AFSC has also worked with industry and the North Pacific Fishery Management Council (NPFMC) to develop other bycatch management measures that would provide substantial incentive for the development of more selective gear types.

A workshop on fishing gear impacts and seafloor mapping was hosted by the ABL of the AFSC and the NMFS Alaska Regional Office. The focus of the workshop was to improve cooperation with other NOAA research conducted by the U.S. Geological Survey, the National Undersea Research Program, and the National Ocean Service. Plans for coordination were developed at the workshop.

The NMML worked closely with the Northwest Regional Office and the Makah tribe to develop methods for deterring the incidental mortality of harbor porpoise in salmon gill nets. The recent development of an acoustic pinger has resulted in a significant reduction in marine mammal bycatch.

Live fish experiments at the Hatfield Marine Science Center in Newport, OR, test fishing gear performance and fish behavioral studies to reduce bycatch and bycatch mortality of prohibited, undersized, or unmarketable species, and to understand performance of survey gear.



Schematic drawing of a commercial bottom trawl that has been modified to reduce bycatch of flatfish in the Alaskan fishery for Pacific cod.

Research Priorities, FY 2001-2006:

- Continue to conduct research to measure direct effects of bottom trawling on seafloor habitat according to a five-year research plan.
- Conduct fishing gear performance and fish behavioral studies to reduce bycatch and bycatch mortality of prohibited, undersized, or unmarketable species, and to understand performance of survey gear.
- Work with industry and the Council to develop bycatch reduction techniques.

III. Research on the fisheries

Recent Accomplishments:

The AFSC conducted socio-economic research to support fishery management actions, particularly those of the NPFMC. The Center's principal accomplishments on socio-economic research were as follows:

- Developed a report on the economic status of the Alaska groundfish fisheries and incorporated it as part of the SAFE reports for the Bering Sea/ Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fisheries.
- Identified and assessed economic consequences associated with alternatives for the programmatic supplemental environmental impact statement (SEIS) for the BSAI and GOA groundfish fisheries.
- Analyzed economic consequences of fishery management actions including additional restrictions on the atka mackerel, pollock, and Pacific cod fisheries to provide additional protection for sea lions through the use of trip limits, stacking groundfish permits, and changing time/area closures to assess interactions between pollock fisheries and sea lions.
- Published research on the decision of fishers to choose fishing locations, marine protected reserves, valuing recreational fisheries, and behavioral modeling of Alaska groundfish fisheries.

The AFSC completed a qualitative assessment of excess fishing capacity in federally managed fisheries off Alaska, assisted in a NMFS national effort to define and measure excess capacity, and revised the guidelines for economic analysis of fishery management actions.

Full utilization of groundfish is mandated by regulation in Alaska. The AFSC contributed to research that led to a ban on roe-stripping and the proper utilization of young fish. The research efforts now concentrate on developing and incorporating aspects of uncertainties associated with stock assessments and ecosystem interactions of the major component species to assess the status, population dynamics, and biological productivity of most of the major groundfish species managed by FMP's in the BSAI and the GOA regions. For example, the effects of variable recruitment and predation needs of marine mammals have been incorporated to provide risk analyses of different exploitation strategies on the Gulf of Alaska pollock stocks so that the stocks are properly utilized.

The AFSC also maintains a fish lab at the Hatfield Marine Science Center at Newport, OR, that conducts research with live fish. The focus of the research is to measure mortality resulting from the capture process of Pacific halibut, sablefish, and juvenile pollock taken as bycatch in trawl and longline fisheries. While the research is focused on impact analyses of human activities on the fish, some of the lessons learned may be useful for aquaculture research. For example, growth and survivorship studies are conducted to study the influence of water temperature on growth of young fish.

Research Priorities, FY 2001-2006:

III.A. Social and economic research

- The AFSC has initiated a data collection program that will collect cost, earning, and employment data for the Alaska groundfish fishery and has worked with the NPFMC, Alaska Department of Fish and Game, and the Alaska Fisheries Information Network (AKFIN) to identify the elements of a broader program to collect economic and social data. This project is continuing to build upon the economic database that is now available.

- Assess the economic impact of different fishing and conservation strategies that are proposed throughout the year by NMFS and the Councils.

- Compile the economic status of Alaska's groundfish fisheries as part of the annual Groundfish SAFE reports.

- Assess economic performance of the Alaska groundfish and halibut fisheries and research to improve these assessments.

III.C. Marine aquaculture

- Study the growth, distribution, behavior, and early marine survival of salmon; and conduct research on salmon biology and enhancement technology in Alaska.

IV. Information management research

Recent Accomplishments:

The AFSC communicates its scientific information and advice, along with the associated uncertainties, to the Councils, other management authorities, and the public. For example, survey results of the AFSC were disseminated to the user groups through the participation of experts at meetings and submission of technical reports and published papers. On a yearly basis, the AFSC publishes roughly 100 scientific papers as well as over a dozen NOAA Technical Memos and Center Processed Reports.

The AFSC and other research units of NMFS used stock assessment workshops, peer reviews, and other fora to ensure that our information and advice are developed through an open and collaborative process. The stock assessment process of the AFSC undergoes periodic review internally and externally throughout the years.

The AFSC provided guidelines to assist the Councils in assessing and specifying MSY for managed fisheries. The AFSC (REFM Division) has the lead role for defining and estimating the MSY levels for all the groundfish stocks managed in

the BSAI and GOA area. The information helps the NPFMC determine the relative status of the stocks to historical levels. The AFSC also has the lead role in defining and estimating the overfishing levels for each of the groundfish stocks managed in the BSAI and GOA area. These maximum fishing levels guide the NPFMC to manage exploitation of the stocks within biologically safe levels.

The AFSC (REFM) provided the technical lead role to develop objective and measurable criteria for stocks that are overfished or approaching an overfished condition. The definitions were used as uniform applications throughout NMFS. These definitions would standardize the criteria for determining depleted stocks due to fishing and other causes throughout the nation.

The AFSC and the Alaska regional office took the lead in developing a comprehensive Bering Sea ecosystem research plan. Two workshops were held in Anchorage to bring together research experts from NMFS, other elements of NOAA, different units from the Department of the Interior, the Environmental Protection Agency, the Alaska Department of Fish and Game, the University of Alaska, the University of Washington, Alaska Native Groups, and other fisheries organizations to share in the planning efforts. This comprehensive research plan can be found at the Bering Sea and North Pacific Ocean Theme page under Interagency Information Exchange at *www.pmel.noaa.gov/bering/pages/inter-agency/*. Additionally a meta-data base of all the research of the different research agencies now resides at *www.pmel.noaa.gov/bering/mdb/*.

Research Priorities, FY 2001-2006:

- Continue to build data infrastructure and resources for easy access and data processing. The AFSC's key data bases are its survey data bases from the 1950's (or earlier) and the scientific observer data base that extends back to the foreign fishing days of the 1960s.

- Continue to provide information products based on experts and technical data that support NMFS, the regional office, the Councils, international scientific commissions, and the overall research and management community.

Northwest Fisheries Science Center (NWFSC)

The Northwest Fisheries Science Center (NWFSC) conducts basic and applied research to support the management, conservation, and development of the Pacific Northwest region's anadromous and marine fishery resources and their habitats. The NWFSC carries out its research from its Montlake Laboratory headquarters in Seattle and from five research stations located in Manchester, Mukilteo, and Pasco, WA, and at Newport and Pt. Adams (Hammond), OR. The Center conducts both field and laboratory research in coastal and estuarine environments of Washington and Oregon, as well as in inland freshwater habitat populated by anadromous species in Washington, Oregon, Idaho, and Montana. The Center also supports annual and triennial groundfish surveys off the west coast.

Northwest Fisheries Science Center's historic 1931 Montlake Laboratory, Seattle, WA.

NOAA R/V *Miller Freeman.*

The NWFSC has several small vessels for conducting field studies. The R/V *Harold Streeter* serves Puget Sound and the R/V *Sea Otter*, R/V *Nerka*, and the R/V *Columbia* serve Columbia River basin projects. The NWFSC relies on the NOAA R/V *Miller Freeman* for some of its research survey data, and also relies on privately chartered vessels and academic research ships to supplement its research capability.

The NWFSC provides the scientific basis to conserve and recover declining Pacific salmon and groundfish populations as well as to address overarching issues such as the impacts of climate shifts, biotoxins, including harmful algal blooms, and toxic chemical pollution on anadromous and marine fishery resources. The NWFSC conducts multi-disciplinary research involving fisheries science, marine biology and ecology, genetics, biochemistry, molecular biology, oceanography, and aquaculture.

Center scientists conduct stock assessments, investigate the impact of bycatch, describe essential fish habitat, and develop new seafood technologies to reduce waste and maximize returns to fishers and processors. Center scientists also develop quantitative models, genetic tools, electronic monitoring devices, hatchery and captive-broodstock rearing techniques, and strategies for safe migration of salmon to the sea. The NWFSC's innovative and original research has helped establish new aquaculture endeavors, seafood processing, dam passage equipment and techniques, methods to detect and evaluate harmful algal blooms, and technology to integrate and track important fisheries dependent data, including fish catch and fish ticket data. The NWFSC's pioneering work on evolutionarily significant units (ESUs) helped define the science of salmonid stock identification under the Endangered Species Act (ESA).

NWFSC research supports critical management decisions on the conservation and recovery of Pacific salmon and groundfish populations, contaminant management, and seafood safety issues. Center scientists are leading west coast recovery efforts for salmon listed under the ESA, providing the scientific information necessary to determine whether certain salmon and groundfish species should be listed as endangered or threatened, understanding crucial links between habitat conditions and species productivity, developing plans to rebuild overfished groundfish stocks, and delivering the science necessary to develop or revise national policies on contaminants, bycatch, fisheries dependent data collection, fishery closures, harmful algal blooms, and other issues. Center scientists are also conducting social and economic studies to support the fishery management process.

Center research is used by the Pacific Fishery Management Council (PFMC) to build and maintain sustainable fisheries through the development of regional fishery management plans and subsequent amendments. NWFSC scientists relay applicable research results through their participation in committee meetings of the PFMC, Pacific Salmon Commission, and the Pacific States Marine Fisheries Commission (PSMFC), as well as other national and international fora, including National Stock Assessment panels and workshops. NWFSC research also supports national and international efforts, including the U.S. GLOBEC program.

The NWFSC nurtures and maintains strong collaborative relationships with other Federal agencies, industry, environmental groups, Native American tribes, individual fishers, universities, and other research and academic institutions. The NWFSC conducts annual groundfish surveys in collaboration with industry and provides west coast specific research needed by other line offices within NOAA (e.g., National Ocean Service) as well as other Federal agencies (e.g., the Bonneville Power Administration and the Army Corps of Engineers). The NWFSC, working with the Northwest Indian College (NWIC), the Department of Commerce, and NOAA, established the National Indian Center for Marine and Environmental Research and Education (NICMERE). NICMERE provides training at the NWIC and NWFSC for students from the 40 tribes served by the NWIC, and also to students from Tribal Colleges and Universities (TCUs) throughout the nation through a distance learning network. The Center also sponsors numerous students in marine research, technology, and library science through cooperative research agreements with regional universities and technical schools.

Recent Accomplishments and Research Priorities for FY 2001-2006

I. Research to support fishery conservation and management

Recent Accomplishments:

Comprehensive research plans for west coast groundfish and Pacific salmon were developed to ensure that all relevant scientific information is available to regional managers and policy makers. Scientists outside the agency, as well as other NMFS Centers, reviewed and provided comments on these documents.

The NWFSC conducted extensive assessments of west coast groundfish species and analyzed the potential for rebuilding species classified as overfished.

A new observer program for west coast groundfish was established. In partnership with the PSMFC, this program is the first new coastwide observer program launched from the NWFSC and implements a new electronic system for capturing and communicating fishery-dependent data. NWFSC also has begun management of the ongoing Pacific whiting observer program.

Salmon Technical Recovery Teams (TRTs) were established in three geographic regions—Puget Sound, Willamette/Lower Columbia River, and the Columbia Basin. TRTs are developing biological criteria for delisting salmon populations and will assist in the development of recovery plans. TRTs are chaired by NWFSC researchers and are composed of scientists from Federal, state, county, city, tribal organizations, and universities. The NWFSC also created a Recovery Science Review Panel, composed of renowned external scientists, to help ensure integrity and consistency in the scientific aspects of recovery planning.

Research Priorities, FY 2001-2006:

I.A. Biological research concerning the abundance and life history parameters of fish stocks

- Develop biologically-based delisting goals for listed salmon and steelhead. This action will be carried out by the Puget Sound, Willamette/Lower Columbia River, and Columbia Basin TRTs for ESUs of Pacific salmon that are listed as threatened or endangered under the ESA.

- Evaluate the direct and indirect effects of nutrients derived from salmon carcasses on salmon populations.

- Apply extinction risk estimates to salmonid populations to establish rationally based priorities for recovery goals.

- Analyze data from trawl surveys, fishery catch, and life history studies to produce reliable assessments of the status of groundfish species.

- Explore and quantify the ecological linkages of salmon distribution and survival in estuarine and near shore environments by studying juvenile Pacific salmon in the Columbia River plume and at Oregon's Cape Blanco.

- Improve west coast groundfish resource surveys and the scientific assumptions on which assessments are based. This will ensure stock assessments more accurately reflect population trends and provide for economic viability of coastal communities, while preventing overfishing.

I.B. Social and economic factors affecting abundance levels

- Expand sociological and economic research and incorporate results into the fishery management process.

- Develop new economic models and analyses to support management decisions.

I.C. Interdependence of fisheries or stocks of fish

- Conduct Genetic Stock Identification (GSI) studies to help determine stock allocation under the Pacific Salmon Treaty, analyze the composition of chinook salmon fisheries in California, help elucidate the ocean migration patterns of listed salmon stocks, and compare different methods of stock identification through computer simulations.

- Develop quantitative and qualitative methods of classifying risk for species of conservation concern through computer modeling and data analysis.

- Assess both the positive and negative effects of hatcheries on wild salmon populations by measuring the relative fitness of hatchery fish and their descendants when they spawn in the wild, developing and applying better models of phenotypic and genetic evolution in hatchery influenced populations, characterizing the genetic consequences of inbreeding within and interbreeding between salmon populations, and developing and applying methods for addressing ecological risks associated with artificial propagation programs.

- Better understand and quantify the importance of genetic diversity within and among salmon populations. Research projects include: (1) measuring the effects of in-breeding in Puget Sound chinook salmon; (2) creating genome maps of chinook and coho salmon and identifying chromosomal regions associated with traits important to adaptation and fitness in species; and (3) determining the usefulness of molecular tools for measuring natural selection and local adaptation.

- Further develop molecular techniques that identify salmon species using DNA markers to identify individual populations within salmon species.

- Use genetic analysis to further investigate the predator/prey relationship between harbor seals and salmon as it relates to recovering some listed salmon populations.

- Estimate the degree of genetic divergence among spawning populations of Pacific hake in Puget Sound and the Strait of Georgia to support decisions to determine the status of distinct population segments for Puget Sound Pacific hake under the ESA, and conduct, if necessary, additional genetic work to better elucidate the population structure of these species.

I.D. Identifying, restoring, and mapping of essential fish habitat (EFH)

- Evaluate the effectiveness of habitat restoration efforts in Washington and Oregon, including evaluating the extent to which placement of structural elements in streams improves habitat quality and increases salmon abundance.

- Develop statistical tools for recovery planning that meld economic costs with biological benefits to ensure that conservation planning is responsive to both economic considerations and biological needs.

- Develop monitoring and evaluation strategies to help determine the rate and success of salmon recovery.

- Determine what aspects of estuarine conditions are critical to salmon survival.

- Define essential fish habitat and assess the impact of fishing gear on stocks

by answering three questions: (1) which habitats are susceptible to gear impacts; (2) what is the relationship between differing levels of fishing activity and habitat degradation; and (3) how can current fishing practices be modified to minimize risks to habitats.

I.E. Impact of anthropogenic factors and environmental changes on fish populations

- Investigate the links between industrial waste, mining activity, pesticide use, and other physical and chemical alterations of coastal and urban habitats on decreased fisheries productivity. Establish threshold values for contaminant effects so biological effects on species can be predicted.

- Investigate the impact of ocean and marine climate variations on salmon by studying salmon distribution, abundance, food habits, and predator-prey relations.

- Determine the impacts of non-indigenous species on salmon by developing new statistical techniques, implementing food web modeling, and conducting field studies and experiments.

- Investigate the effects of chemical contaminants on the growth, development, reproduction, and survival of marine fish and mammals.

- Investigate how natural environmental variations and exposure to contaminants affect juvenile salmon during their passage through estuaries in Washington and Oregon, focusing on how natural and human induced stresses alter growth, neurological function and behavior, and induce disease-related mortality.

- Quantify how salmon use stream and river habitats by collecting descriptive information as well as assessing population responses to different watershed conditions.

- Explore how land use practices such as logging, farming, urban development, and other human activities impact the recovery of threatened and endangered Pacific salmon.

II. Conservation engineering research

Recent Accomplishments:

The adult return of endangered Redfish Lake sockeye salmon was significantly increased. Using captive broodstock technology, juveniles produced from all returning fish (16) during the 1990s were reared and released. Over 250 adults returned this year from the first year class.

A genetic marker for differentiating among strains of bacterial kidney disease (BKD) was identified. Used in combination with other molecular methods, this marker will be a powerful new tool for investigating sources of infection and routes of transmission in both wild and captive salmon.

Passive integrated transponder (PIT) tag technology was expanded in the Columbia River Basin. As a result, it will be possible to install adult salmonid PIT-tag detection systems in all fish ladders at Bonneville Dam by 2002, allowing scientists to make precise estimates of ocean survival of salmon and steelhead.

A collaboration with the net pen industry was established to conduct a two-year risk-benefit assessment of the Puget Sound net pen industry.

Research Priorities, FY 2001-2006:

- Develop conservation hatchery technology to aid recovery of ESA-listed stocks of Pacific salmon. Further develop the Natural Rearing Enhancement System (NATURES), a system for culture of Pacific salmon in raceways that simulate natural environments to develop salmon with characteristics and behavior more like their wild counterparts.

- Develop broodstock technology to restore depleted Pacific salmon stocks. Improve captive broodstock rearing techniques and gauge the potential of hatchery salmon to alter the genetics of wild populations.

- Develop methods to identify and control pathogenic microorganisms, including BKD, that threaten fishery resources, by conducting genetic studies of the bacterial pathogens, characterizing host-pathogen interactions, and developing highly sensitive molecular techniques.

- Determine both the direct and indirect effects of hydropower operations on salmon populations.

- Continue advancing PIT-tag technology to promote safe and efficient fish passage through hydropower systems, and other unnatural barriers, and to gain understanding of migration patterns upsteam and downstream.

III. Research on the fisheries

Recent Accomplishments:

Over 5,000 juvenile lingcod were produced through culture techniques for early life history and habitat preference research.

A new method was developed for producing surimi for human consumption from fillet trimmings of cod, pollock, and underutilized species such as arrowtooth flounder.

A regional aquaculture initiative was drafted to establish codes of conduct and best management practices in coastal waters and the EEZ.

Research Priorities, FY 2001-2006:

III.A. Social and economic research

- Analyze current and historical operating costs and activity patterns in the fishing industry and indicate how each group would be economically impacted by changes in fishing gear use and area restrictions, limits on individual catch, and/or direct allocation between user groups.

NMFS scientist stands near incubation unit for culturing phytoplankton for marine biotoxin studies, Phytoplankton Culturing Laboratory, NWFSC.

III.B. Seafood safety research

- Explore more complete utilization of marine resources by developing methods to recover more flesh from targeted fish species and to identify and control naturally occurring microbial pathogens that limit shellfish harvests.

- Develop methods to identify and analyze marine toxins and the algae that produce them. Ascertain how these toxins are transmitted and their effect on target organisms. Determine the health risks that biotoxins pose for fish and shellfish.

III.C. Marine aquaculture

- Develop laboratory aquaculture techniques for targeted marine species, by studying aquaculture engineering, fish physiology, nutrition, pathology, and developmental biology to relieve pressure on severely depressed wild marine stocks.

IV. Information management research

Recent Accomplishments:

The Alpha-level Electronic Fish Catch Logbook Project (EFCL) system was demonstrated to the states of California, Oregon, and Washington and to fishers and fish processors. Fishers requested that the NWFSC develop an electronic system to allow better use of data that fishers and processors are already required, by state law, to collect. Users wanted to be able to enter fish catch landing data electronically and to use computers to communicate and track fishing locations in real time, or near-to-real time. This system can improve fisheries management and support better fishing practices.

A salmon data team was created and launched to improve Pacific salmon data management, data access, and data sharing between parties and institutions.

Research Priorities, FY 2001-2006:

- Complete the current development effort of the EFCL with on-vessel beta testing.

- Integrate all data on salmon stocks in Washington, Oregon, and California generated by ESA status reviews with data maintained in the StreamNet database. The NWFSC has created an interagency salmon data team to develop a comprehensive management model. The model's purpose is to anticipate multi-species impacts resulting from changes in environmental and fishing regimes and to support tribal fishery managers with data and analysis that focuses on maintaining long-term viability and genetic diversity of local breeding populations.

- Develop statistical approaches to improve monitoring and evaluation of threatened or endangered species.

- Improve Cumulative Risk Initiative web-based reporting system outputs by strengthening links to raw data and other information sources.

- Provide support for area school systems interested in implementing salmon genetics curricula as well as vocational programs for training technicians.

Southwest Fisheries Science Center (SWFSC)

The Southwest Fisheries Science Center (SWFSC) headquarters is located in La Jolla, CA, and research is conducted at laboratories in La Jolla, Santa Cruz, and Pacific Grove, CA, and Honolulu, HI. The current staffing level involved in MSFCMA-related activities is at about 156 full-time equivalents (FTEs). An estimated 65% of total SWFSC resources are assigned to direct MSFCMA activities. NOAA research vessels assigned to fisheries research in the SWFSC are the NOAA R/V *Townsend Cromwell*, assigned to the Honolulu Laboratory, and the NOAA R/V *David Starr Jordan*, which has San Diego, CA, as its homeport. In addition about two-thirds of the NOAA vessel *McArthur*'s time is used by the Center.

Southwest Fisheries Science Center, La Jolla Laboratory and Headquarters, La Jolla, CA.

The SWFSC is a world-class research organization which conducts integrated, multi-disciplinary research programs in biology, mathematics, oceanography, and economics for the purpose of developing scientific technology and information to support the management and allocation of Pacific coastal, central and western Pacific insular, coral reef, and high-seas fishery resources. These activities support the scientific, statistical, and economic needs of the Western Pacific and the Pacific Fishery Management Councils and international commissions for large pelagic fishes and Antarctic resources. Center programs also support efforts directed toward the reduction of protected species interactions, fishery-related porpoise mortality, and a better understanding of the biological and environmental factors affecting the marine resources exploited by U.S. commercial and recreational fisheries. The Center provides the scientific information necessary to conserve

and manage the following important fisheries in the Pacific and Antarctic regions:

- Large pelagic fishes of the Pacific Ocean (tuna, billfish, shark, and swordfish).
- Crustaceans of the central Pacific (lobster).
- Precious corals of the central Pacific.
- Bottomfish and seamount species of the western Pacific.
- Groundfishes of the west coast (Pacific hake, rockfishes, lingcod).
- Small coastal pelagic species of the west coast (northern anchovy, sardine, mackerel, squid).
- Salmon of the west coast.
- Antarctic krill, crabs, squid, finfish including Patagonian toothfish.

The Southwest Fisheries Science Center specializes in fisheries of the California Current, Pacific oceanic, and Antarctic regions. Research is carried out on the ecology, population dynamics, fisheries, and stock assessment of small coastal pelagic species, west coast groundfishes, billfish, tunas and sharks, and California salmon. The Center maintains and utilizes the largest database on tuna and tuna-related fisheries in the world. The Center makes extensive use of biological and fisheries data, which are collected by observers placed on fishing vessels by the Southwest Region, to monitor interactions with protected resources to achieve goals related to the MSFCMA. It is also considered a leader in fish survey design, conducting surveys to monitor early recruitment success of economically important fish stocks along the U.S. west coast. It is a co-participant in the State-Federal California Cooperative Fisheries Investigations, a comprehensive long-term study of the biology and oceanography of the California Current. In the oceanic Pacific, the Center is the leading source of stock assessment expertise on tropical island and oceanic resources, especially bottomfishes, lobster, tunas, sharks, and billfishes and cooperates with the University of Hawaii and the Western Pacific Fishery Management Council (WPFMC) in undertaking the Western Pacific Pelagics Research Program. The SWFSC is also leading a multi-partner research and long-term monitoring effort to assess the health of the Nation's largest coral reef resource and to mitigate the impact of marine debris on the coral reef ecosystem of the Northwest Hawaiian Islands (NWHI). In the Antarctic, the SWFSC leads U.S. research directed at gathering ecological information to prevent overexploitation of fish and krill and to protect Antarctic living marine resources. The SWFSC provides oceanic environmental data and indices to the rest of NMFS as well as to other Federal, state, academic, and foreign fisheries scientists. Center scientists are leaders in the research and development of fisheries-relevant environmental data products. The SWFSC is home to two NOAA CoastWatch nodes at its Honolulu and La Jolla laboratories.

NMFS scientist conducts *in situ* coral reef study.

SWFSC scientists have taken the lead in characterization of large- and small-scale habitats that support groundfish and bottomfish populations in deep water. This work requires an interdisciplinary approach from fishery biologists, geologists, and ecologists and couples the use of GIS with remote-sensing acoustic tools, *in situ* survey techniques using submersibles, and spatial analyses. This approach is being applied to the identification of EFH, the improvement of stock assessment

surveys, and the evaluation of MPAs as an effective supplement to traditional fishery management. The National Ocean Service's MPA Center is cooperatively co-located with the SWFSC's Santa Cruz Laboratory.

The SWFSC maintains an active communications network with constituents, colleagues in the scientific professions, and the public to receive input for research planning, execution, and results. The network includes frequent dialogue with commercial and recreational fishers, leaders of environmental groups, participants of fishery management councils, state and Federal research agency staff, and outside scientists in the United States and foreign countries. Supporting this network is an infrastructure that includes cooperative agreements to support collaborative work with researchers in state agencies, universities, and foreign governmental agencies for collecting logbook and other types of fisheries data and for shared research projects; arrangements for data exchange; and contracts for charters of research vessels and specialty expertise. The SWFSC and its laboratories maintain up-to-date Internet sites that provide a range of information, including scientific reports and summary data bases available to other researchers as well as the general public.

The SWFSC provides scientific and research support for U.S. commitments resulting from the following international arrangements and agreements in the Pacific region: (1) Convention for the Conservation of Antarctic Marine Living Resource (CCAMLR), which manages the marine living resources of the Antarctic; (2) Inter-American Tropical Tuna Commission (IATTC), which deals with tuna and tuna-like fishes, and the tuna-dolphin issue of the eastern Pacific Ocean; (3) South Pacific Tuna Treaty (SPTT), which provides tuna fishing access to the western Pacific Ocean; (4) North Pacific Interim Scientific Committee for Tuna and Tuna-like Species (ISC), which promotes research on tuna and tuna-like species of the North Pacific Ocean; (5) Standing Committee on Tuna and Billfish of the Secretariat of the Pacific Community (SCTB), which facilitates collaborative research on tuna and billfish of the western Pacific Ocean; (6) MEXUS-Pacifico, which promotes joint U.S.-Mexico research projects of mutual interest; (7) North Pacific Albacore Workshop (NPALB), which promotes stock assessment research for north Pacific albacore; (8) Commission on the Conservation of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (MHLC), which will manage the highly-migratory fish resources of the western and central Pacific Ocean; and (9) International Whaling Commission (IWC), which promotes conservation of whale stocks. In addition, SWFSC scientists periodically work jointly with other scientists on projects sponsored by international organizations such as the UN Food and Agriculture Organization (FAO), Global Ecosystem Dynamics (GLOBEC), and the North Pacific Marine Science Organization (PICES).

The Southwest Fisheries Science Center maintains an exceptional fisheries economic research capability. Special studies are undertaken to help explain and evaluate the potential impacts of various management options on components of the fishery or the public. In addition, economic data collection and analyses are carried out to evaluate the economic health of fisheries or components of the fisheries.