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NMFS STRATEGIC PLAN FOR FISHERIES RESEARCH
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NMFS Strategic Plan for Fisheries Research

February 2004

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

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NATIONAL MARINE FISHERIES SERVICE

Mission Statement

Stewardship of living marine resources through
science-based conservation and management
and the promotion of healthy ecosystems

PREFACE

The National Marine Fisheries Service (NMFS) is responsible for the science-based management, conservation, and protection of living marine resources within the United States Exclusive Economic Zone (EEZ). As one of the key elements of the National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce, NMFS is also known as NOAA Fisheries.

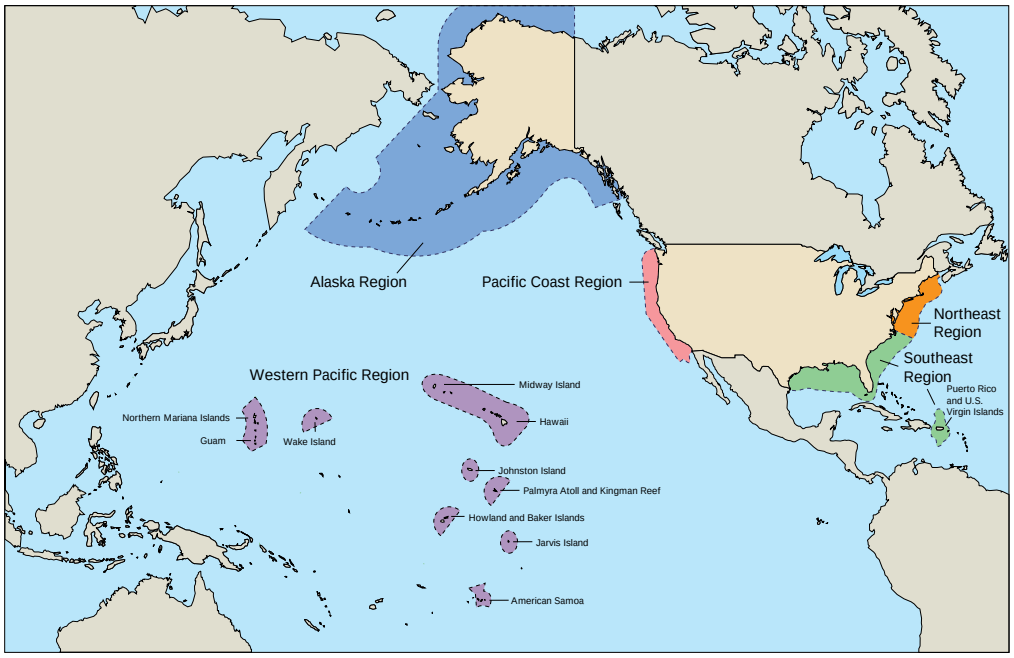


Figure 1. The U.S. Exclusive Economic Zone.

The U.S. EEZ is the largest in the world, encompassing 1.7 times the area of the United States and territorial landmass (Fig. 1). The EEZ is located 3–200 nautical miles (n.mi.) seaward of the 48 contiguous states, Alaska, Hawaii, and US-affiliated islands except off Texas, the Florida Gulf Coast, and Puerto Rico where the EEZ extends 9–200 n.mi. The EEZ is composed of at least eight Large Marine Ecosystems (NE & SE continental shelf, Caribbean Sea, Gulf of Mexico, California Current, Insular Pacific Hawaiian, Gulf of Alaska, and Eastern Bering Sea). Fisheries have developed in the United States as each area was settled, whether by the original aboriginal peoples or the post-Columbian arrivals. Inshore marine fisheries are managed by states, regional Marine Fisheries Commissions, and even some municipalities and counties in some areas. Fisheries in the EEZ beyond state jurisdiction (3 n.mi. in most states) are the responsibility of the Federal government, specifically NMFS in concert with eight Fishery Management Councils (FMCs). Information about this system of management is available at http://www.nmfs.noaa.gov/sfa/sfweb/index.htm.

In addition to its primary responsibilities within the EEZ, NMFS also plays a supportive and advisory role in the management of living marine resources in coastal areas under state jurisdiction, provides scientific and policy leadership in

Handling a trawl net.
Photo: AFSC.

the international arena, and implements international conservation and management measures as appropriate.

The agency's long-term commitment to scientific excellence via internal and external peer-reviewed scientific publications has materially advanced marine science and policy for over 130 years. Since 1871, Federal fisheries scientists have collected, researched, analyzed, and published peer-reviewed data on the Nation's living marine resources, marine ecosystems, and the benefits that they provide. Under this peer-review process, important agency findings are published in many highly respected journals. Recently, NMFS has instituted a science quality assurance program to consistently monitor and review NMFS research efforts to ensure that they are of the highest quality. Further, this program identifies gaps in infrastructure, facilities, and resources that may affect the productivity of NMFS scientists.

The NMFS Scientific Publications Office (SPO) and the Scientific Editor ensure the editorial and scientific integrity of the Agency's research products: peer-reviewed journals, professional papers, and technical memoranda. These products and other regional NMFS publication materials serve as the basis for agency scientific reports, regulatory documents, and technical presentations available to fishery scientists and managers, the commercial and recreational fisheries interests, environmental groups, the information community (media), and the public. Thus, the agency's comprehensive scientific research and publishing efforts provide the foundation for developing sound policies that govern the use, protection, restoration, and conservation of living marine resources, marine habitats, and related aquatic environments.

This document builds upon significant internal planning initiatives and external reviews.

Examples of SPO publications.

Commercial troller off the California coast. Photo: Allen Shimada, NMFS.

INTRODUCTION

As in any organization, planning takes place at multiple levels, and requires both awareness of and consistency with the goals and perspectives specific to the different levels. Within NOAA, there is a strong central plan (NOAA Strategic Plan) setting forth the missions, goals, and expectations of the total organization overall. Each NOAA line office (e.g., NMFS) then has its own subordinate plan to outline the mission it serves and link with appropriate parts of the NOAA Strategic Plan. Within the NOAA line offices, additional plans are prepared to implement programs specified at higher levels. The NMFS Strategic Plan for Fisheries Research (NSPFR) is such a document. This plan must address the intent of Congress as expressed in legislation while maintaining consistency with the research and management framework established within NOAA. As such, this document incorporates research planning elements across four NOAA levels: from the overarching NOAA Strategic Plan, to the NOAA Fisheries Strategic Plan (NFSP), to this NSPFR, and lastly, to the six Fisheries Science Center research plans.

The scope of the NSPFR is specific to the requirements of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) with respect to fisheries, habitat, and protected resources research. It does not include the regulatory and enforcement components of the NMFS mission. This Plan updates the 1998 (original) and 2001 editions of the NSPFR. It covers current research activities as well as strategies for improving data collection, analysis, and dissemination.

This Plan represents an integration of multiple perspectives on the fisheries research needs of American society drawn from numerous sources. The NMFS research planning process itself includes extensive communication with our partners (e.g., fisheries management councils, the states, and other governmental organizations) and our constituents. NMFS research programs are periodically reviewed by informal and formal program reviews, with both internal and external participation. NMFS scientists serve on Fishery Management Council scientific committees, plan development teams, and boards where research inadequacies are identified firsthand. Regulatory and judicial proceedings also identify information needs that are then incorporated in the research programs. Finally, NMFS scientists work together with international counterparts to identify and fill information gaps that otherwise constrain management of marine resources both domestically and on the high-seas.

Relationship Between the NOAA Strategic Plan and NMFS Programs

THE NOAA STRATEGIC PLAN: NEW PRIORITIES FOR THE 21ST CENTURY

NOAA has recently updated the structure and content of its strategic plan to better address NOAA mandates. NOAA's focus through 2008 will be on four Mission Goals:

1. Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management.
2. Understand climate variability and change to enhance society's ability to plan and respond.
3. Serve society's needs for weather and water information.
4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation (NOAA, 2003).

In an effort to build specific core strengths, NOAA has selected six core capabilities called "Cross-Cutting Priorities For The 21st Century" that it recognizes as closely allied and essential to support its four mission goals

- Integrated Global Environmental Observation and Data Management System;
- Environmental Literacy, Outreach, and Education;
- Sound, Reliable, State-of-the-Art Research;
- International Cooperation and Collaboration;
- Homeland Security; and
- Organizational Excellence.

Virtually all of the NMFS programs, including the research programs, are encompassed entirely within NOAA's Mission Goal 1, focused on coastal and ocean resources. However, many NMFS programs have outputs that also serve the Cross-Cutting Priorities. By being attuned to broader needs, program managers can ensure additional benefits are obtained. Nevertheless, the primary purpose of nearly all NMFS programs is to accomplish a specific requirement within Goal 1, usually as mandated by legislation. The two exceptions are the seafood inspection activities that are now identified as specifically supporting the Homeland Security Cross-Cutting Priority and climate-related research on ecosystem productivity that resides in Goal 2.

NOAA has identified three strategic objectives under Goal 1:

- Protect, restore, and manage the use of our ocean, coastal, and Great Lakes resources.
- Protect, restore, and manage species and their habitats listed under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA).

A beluga whale fitted with a tracking device. Photo: AFSC.

- Manage and rebuild fisheries to population levels that will support economically viable and sustainable harvests.

Indicators of progress (outcome measures) are:

- Increased number of coastal and marine ecosystems maintained at a healthy, sustainable level.
- Increased social and economic value of the marine environment and resources (e.g., seafood, recreation, and tourism).
- Increased number of acres and stream-miles restored for coastal and ocean species.
- Increased number of protected species in a stable condition or an upward trend.
- Increased number of managed species that are at optimum levels.
- Improved ecological conditions in coastal and ocean protected areas.

The summary and full versions of the Plan are available at http://www.osp.noaa.gov/.

Relation of the NOAA Fisheries Strategic Plan and This NMFS Strategic Plan for Fisheries Research

The NFSP (Priorities for the 21st Century: NOAA Fisheries' Strategic Plan for FY 2003–FY 2008) guides NMFS activities in support of NOAA's mission and its underpinning goals and objectives. It interweaves with the NOAA Strategic Plan by establishing indicators of progress, and their associated performance measures and metrics in the context of NOAA's Strategic Goal 1. Details regarding the NFSP are available at http://www.nmfs.noaa.gov/mb/.

The NFSP requires the support of research to meet most of its objectives. As an Agency-wide strategic plan, it must address all relevant legislative mandates, and closely correspond to the NOAA Strategic Plan. However, the NSPFR has a somewhat different structure that is specific to the content mandated by the MSFCMA.

This NSPFR guides the suite of programs that address the research objectives of NMFS necessary to implement the MSFCMA as amended by the Sustainable Fisheries Act (SFA). This encompasses much of NMFS research activities regarding fisheries and habitat issues and includes specific Fisheries Science Center plans as well. Research on marine mammals, turtles, and protected species of fish, such as the endangered white abalone and shortnose sturgeon, is included but only when it is directed at MSFCMA requirements.

The following table (Table 1) presents the outline of this MSFCMA-required research strategic plan in the left column and shows how the corresponding strategies and their elements of the NFSP relate to it on the right. A similar table included as Appendix A presents the outline of the NFSP strategies and elements and shows how the corresponding elements of the MSFCMA-required research plan relate to the broader Agency plan.

Overview of Planning Documents

Over the last several years there have been numerous outside reviews of NMFS research programs and plans have been developed to implement the recommendations of these reviews. These program-specific reviews and plans have greatly influenced this present Plan. Overviews of the more important reviews and plans are presented below.

Internal Planning Documents:

- *Requirements for Improved and Integrated Conservation of Fisheries, Protected Resources and Habitat* (January, 2003).

Many internal and external reports have evaluated the science and management of

NMFS Strategic Plan for Fisheries Research	NOAA Fisheries Strategic Plan
I. Research to support fishery conservation and management	
I.A. Biological research concerning stock abundance	Monitor and Observe: - Observers - Observing Platforms/Advanced Technology - Industry Partnerships Assess and Predict: SAIP Implementation
I.B. Social and economic factors affecting abundance levels	Monitor and Observe: Social Science
I.C. Interdependence of fisheries or stocks of fish	Assess and Predict - Ecosystem Modeling
I.D. Identifying, restoring, and mapping of essential fish habitat	Monitor and Observe: Habitat Assessments/ Restoration Monitoring
I.E. Impact of anthropogenic factors and environmental changes on fish populations	Understand and Describe: - Habitat - Marine Noise
II. Conservation engineering research	Manage: Bycatch Reduction
III. Research on the fisheries	
III.A. Social and economic research	Monitor and Observe: Social Science Understand and Describe: Economics and Social Sciences
III.B. Seafood safety research	Cross-Cut Priorities: Homeland Security
III.C. Marine aquaculture	Manage: Aquaculture
IV. Information management research	Monitor and Observe: Fisheries Information System

Table1. Comparing the NSPFR and the NFSP

NMFS and made recommendations for improvements. In light of these different reports and recommendations, NMFS has produced a single requirements document that outlines specific changes in programs, processes, and strategies over the next 5 years that should be made in an integrated manner. Both the funding and expected outcomes above and beyond current efforts are described. The report focuses on the science and management changes needed to achieve the stewardship goals of rebuilding and sustaining marine and anadromous fisheries, and satisfying our protected species and habitat conservation mandates. An Executive Summary is being finalized and will soon be available at http://www.nmfs.noaa.gov/mb/ (NMFS, 2003d).

Sorting a survey catch from Seguam Pass in the Aleutian Islands. Photo: Jay Orr, AFSC.

- *NMFS Marine Fisheries Stock Assessment Improvement Plan* (SAIP) (October 2001)
  The Marine Fisheries SAIP is the report of the NMFS National Task Force for Improving Fish Stock Assessments. This report is the latest of a series of plans for enhancing and modernizing NMFS programs for data collection, information technology, data management, stock assessments, scientific research, and fisheries management. The report includes specific recommendations for improving the quality of NMFS' stock assessment programs and emphasizes the need for the agency to foster partnerships and cooperative research programs with other federal agencies, state agencies, private foundations, universities, commercial and recreational fishing organizations and individuals, environmental groups, and others with a vested interest in collecting similar types of data. Recommendations from the SAIP have formed the basis for successful budget initiatives to augment funding for improving stock assessments. The SAIP is available at: http://www.st.nmfs.gov/st2/saip.html (NMFS, 2001).

- NM*FS Strategic Plan for Fisheries Research* (1998 and 2001)
  Originally released in 1998 as a requirement of the Sustainable Fisheries Act of 1996, these first two Plans were purposely framed to be consistent with previous planning initiatives, yet with a more detailed focus on NMFS research activities. In particular, the Plans functioned as a subset of the NFSP. The objectives found under the "Major Fishery Research Goals and Objectives" section of the Plans can be matched with strategies in the previous NFSP (1997). The 1998 NSPFR is available at www.nmfs.noaa.gov/sfa/stratpln.pdf. The 2001 Plan is available at http://www.st.nmfs.gov/st2/strategic_plan.html.

- *NOAA Fisheries Data Acquisition Plan* (1998)
  Released in September of 1998, this document represents a 5-year strategy for meeting NMFS' rapidly growing at-sea data requirements. The Plan provides an overview of the existing data acquisition program, describes anticipated growth and changes to data requirements in the future, details options available, and presents a suite of recommendations for meeting these challenges, including the construction of a fleet of modern Fisheries Research Vessels. Recommendations from the Plan have formed the basis for budget decisions relative to the acquisition of at-sea data. This Plan is available from the NMFS Web site at http://www.st.nmfs.gov/st2/omb_link.html.

External Reviews by the National Research Council (NRC)

- *Improving Fish Stock Assessments* (1998)
  Published in 1998, this report commissioned by NMFS reviews the agency's current stock assessment methods and models and makes recommendations for alternative approaches. The objective of the review was to produce an authoritative report that documented the strengths and limitations of stock assessment methods relative to the diversity of available data and types of fisheries management systems. The report can be read on-line or purchased at the National Academy Press Web site at www.nap.edu/ (NRC, 1998).

- *Sustaining Marine Fisheries* (1999)
  Published in 1999, this NRC commissioned report explores the nature of marine ecosystems and the complex interacting factors that shape their productivity. The book documents the condition of marine fisheries in 1999, highlighting species and geographic areas that were under particular stress. Challenges to achieving sustainability are discussed, and shortcomings of existing fisheries management and regulation are examined. The report calls for fisheries management to adopt a broader ecosystem perspective that encompasses all relevant environmental and human influences, but also emphasizes that the first step towards ecosystem-based management is to reduce fishing mortality on individual stocks to optimal levels. It can be read on-line or purchased at the National Academy Press Web site at www.nap.edu/ (NRC, 1999). While this report was not a specific review of NMFS science and management efforts, it sought and made recommendations on how the ecosystem approach should be used and is thus useful in guiding NMFS research programs.

- *Improving the Collection, Management, and Use of Marine Fisheries Data* (2000)
  Published in 2000, this NRC commissioned report assesses methods for improving data for stock assessments and fisheries management. The summer flounder fishery was used as a case study in this report because it supported a fishery that spanned state and Federal waters over a vast geographic area, both recreational and commercial fishermen targeted the species, and there was an abundance of data available for assessments. The report analyzed summer flounder stock assessments and implicit and explicit modeling assumptions that affected modeling outcomes. The study also examined data collection and use and made 40 recommendations to Federal and state fishery agencies, Congress, regional FMCs, interstate commissions, and commercial and recreational fishermen with the objective of improving fisheries data and management. This report can be read on-line or purchased from the National Academy Press at www.nap.edu/ (NRC, 2000).

- *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems* (2001)
  Published in 2001, this NOAA-commissioned report evaluates marine protected areas (MPAs) as a tool to supplement conventional fishery management. The report recommended networks of MPAs, some for fishery management, embedded within broadly zoned management areas in the coastal ocean. Additionally, the study indicated that the basic knowledge gained through monitoring and evaluation of MPAs on the structure, function, and variability in marine

ecosystems would enhance the design of reserves and allow more accurate evaluations of their ecological and socio-economic consequences. Reserves would also allow more accurate estimation of parameters such as natural mortality rates—an essential variable in stock assessment models. This report can be read on-line or purchased at the National Academy Press Web site at www.nap.edu / (NRC, 2001). While this report was not a specific review of NMFS science and management efforts, it sought and made recommendations on how MPAs should be used and is thus useful in guiding NMFS research programs.

Legislative Background

The United States Congress reauthorized the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), as amended by the Sustainable Fisheries Act (SFA), on October 11, 1996. Section 404 (Fisheries Research) of the MSFCMA requires the Secretary of Commerce to develop and publish in the Federal Register a strategic plan for fisheries research for the five (5) years immediately following such publication. The Act stipulates that the plan:

- Identify and describe a comprehensive program with a limited number of priority objectives for research in each of the research areas specified below.

- Indicate goals and timetables for the program.

- Provide a role for commercial fishers in such research, including involvement in field testing.

- Provide for collection and dissemination, in a timely manner, of complete and accurate information concerning fishing activities, catch, effort, stock assessments, and other research conducted under this section.

- Be developed in cooperation with the fishery management councils and affected states, and provide for coordination with the councils, affected states, and other research entities.

The MSFCMA requires the comprehensive program to contain the following research areas:

- Research to support fishery conservation and management, including but not limited to:

  - biological research concerning the abundance, trends, and life history of fish stocks,
  - the interdependence of fisheries or stocks of fish,
  - the identification of essential fish habitat,
  - the impact of pollution on fish populations,
  - the impact of wetland and estuarine degradation, and
  - other factors affecting the abundance and availability of fish.

- Conservation engineering research, including:

  - the study of fish behavior,
  - the development and testing of new gear technology and fishing techniques to minimize bycatch and any adverse effects on essential fish habitat, and
  - the promotion of efficient harvest of target species.

- Research on the fisheries, including:

  - the social, cultural, and economic relationships among fishing vessel owners, crew, U.S. fish processors, associated shoreside labor, seafood markets, and fishing communities.

- Information management research, including:

  - the development of a fishery information base and an information management system under Section 401 that will permit the full use of information in the support of effective fishery conservation and management.

Performance Measures

The NOAA Strategic Plan (NOAA, 2003) contains a series of performance measures for each goal. As of the preparation of this Plan, NMFS is developing supporting measures for inclusion in the NFSP (NMFS, 2003b) to contribute towards those at the NOAA level. The NOAA measures that impact the NSPFR are:

GOAL 1: PROTECT, RESTORE, AND MANAGE THE USE OF COASTAL AND OCEAN RESOURCES

Objective A. Protect and Restore Ocean, Coastal, and Great Lakes Resources

Strategy: Monitor & Observe

- Increased area covered and number of ecological conditions monitored by state-of-the art observation systems and platforms that provide necessary information for NOAA's stewardship responsibilities

Strategy: Understand & Describe

- Increased ocean, coastal, and Great Lakes areas explored, mapped, characterized, and inventoried

- Increased number of impacted human communities where sufficient data exist to analyze and understand the economic and social benefits, costs, and impacts of management decisions

- Increased number of techniques and tools that can be used to restore and protect ocean, coastal, and Great Lakes resources

- Increased number of marine resources potentially available for commercial use (e.g., pharmaceuticals, aquaculture species for human uses)

Strategy: Assess & Predict
- Increased number and accuracy of models to understand and predict the interactions of species and their environment

Objective B: Recover Protected Species

Strategy: Understand & Describe
- Increased number and adequacy of techniques and tools that can be used to restore and conserve protected species

Objective C: Rebuild and Maintain Sustainable Fisheries

Strategy: Monitor & Observe
- Increased number of fish species with adequate information to assess their condition

Strategy: Understand & Describe
- Increased number of fish species where the biological and ecological factors related to population abundance are adequately understood for management purposes

- Increased number or adequacy of techniques (including stock enhancement) and tools that can be used to restore and conserve fish species

Strategy: Assess & Predict
- Increased number of fish species with adequate population assessments, including adequate estimates of fishing or other sources

- Increased number of species whose essential fish habitat is adequately mapped and understood

- Increased use of physical-biological models for forecasting stock abundance

GOAL 2. UNDERSTAND CLIMATE VARIABILITY AND CHANGE

Strategy: Assess & Predict
- Increased number of new indicators of climate impacts on marine ecosystems

CROSS CUTTING PRIORITIES

Sound, State-of-the-Art Research

- Increased use of models and assessments among scientists, economists, social scientists, operations, and ecosystem managers

Homeland Security

- Increased number of ships with vessel monitoring systems

COMPREHENSIVE FISHERY RESEARCH PROGRAM

The Science Enterprise

The National Marine Fisheries Service develops information needed for the science-based stewardship of the Nation's living marine resources. The six NMFS regional Science Centers encompass 25 principal laboratories, employing over 1,550 scientific and support personnel who conduct a comprehensive, interdisciplinary science program. The scope of their work is temporally and spatially broad and multidisciplinary. The Science Centers provide the scientific knowledge base on which NMFS formulates stewardship policies in concert with its six Regional Offices. Research at NMFS laboratories supports resource management in NOAA, fishery management councils, interstate fishery commissions, and other agencies to facilitate informed decision-making about 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 across Science Centers. Each Science Center develops its own annual research priorities, based upon regional and national needs. The research plans are updated as necessary in consultation with the Regional Offices, Councils, the Program Offices in NMFS headquarters, and NOAA's constituents. The Science Center research staffs are generally organized into teams that focus on specific issues or areas of expertise.

The Office of Science and Technology coordinates the overall NMFS integrated research program. The Science Board, composed of the six 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 the research capability of NMFS. Many NMFS scientists serve as university adjunct professors. This relationship enhances the ability of 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 NMFS research program quality and relevance. The Science Centers work in cooperation with other Federal and state agencies, international entities, nongovernmental 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 initiatives focus on the needs of the FMCs (e.g., determination of the correct mesh size for a specific fishery or determination of the timing and area limits for a specific closure) and on the needs of the NMFS Habitat Conservation field offices to meet their scientific and management mandates under the EFH provisions of the MSFCMA.

The mission of the NMFS scientific enterprise is to ensure that the science products produced and disseminated by the National Marine Fisheries Service are of the highest possible quality. These products reach the decision process through various ways. They include FMC meetings, Technical Committee meetings, written documents that are printed or published on the Web, presentations to policy makers in other fora, and workshops convened to attack specific problems.

Research Components

The MSFCMA mandates strong action to conserve and manage fishery resources that contribute to the food supply, economy, and health of the Nation's marine ecosystems. MSFCMA provisions require NMFS to end overfishing, rebuild all overfished stocks, and conserve essential fish habitat through research and consultations on Federal and state actions that may adversely affect such habitat. These are among our primary stewardship responsibilities.

NMFS is responsible for ensuring that management decisions are based on the highest quality scientific information on the biological, social, and economic status of the fisheries. This includes species' responses to environmental changes, exploitation, and other human activities that affect them and their habitat. Social, cultural, and economic behaviors and incentives that influence human / marine interactions are also addressed. The information is used not just for current management decisions, but also to conserve resources and anticipate future trends, assure future utilization opportunities, and assess the success or failure of the agency's management efforts.

NMFS is also responsible for ensuring that this information, and thus the management decisions for which it provides the foundation, is understood and its validity accepted by user groups and other constituents. To accomplish this, the MSFCMA has mandated that we provide a role for commercial fishers in our fisheries research. An obvious role is in operating charter surveys, but less visible means include providing information and knowledge about changes in species abundance and distribution, ideas and testing of bycatch reduction technology, and reviewing assessment methods and results.

The research priorities of NMFS may be grouped into the four major areas (with several subareas) defined by Congress (see Legislative Background):

I. Research to support fishery conservation and management
II. Conservation engineering research
III. Research on the fisheries
IV. Information management research

More resources are devoted to research underlying conservation and management than all the other areas combined.

I. Research to Support Fishery Conservation and Management

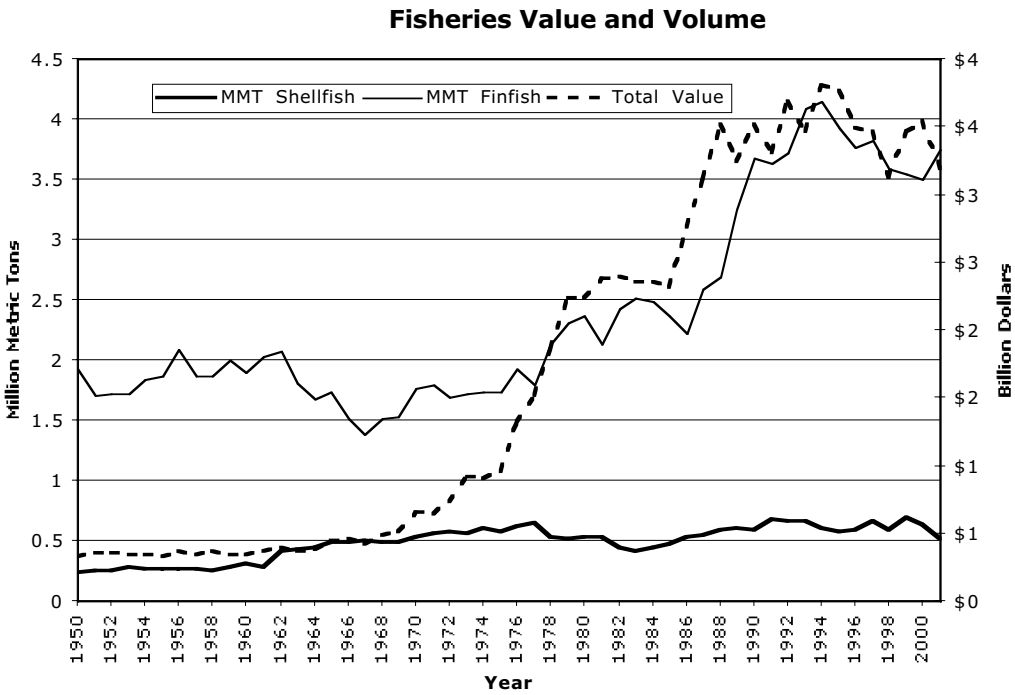
Living marine resources (LMRs) currently support extensive commercial, recreational, and subsistence uses. In 2001, commercial landings by U.S. fishers were 9.4 billion pounds valued at $3.1 billion and U.S. consumers spent about $55 billion for fishery products. The 2002 U.S. marine recreational fish catch was an estimated 420 million fish taken on an estimated 72.0 million fishing trips by more than 12 million Americans (NMFS, 2003e). Once the value-added benefits are calculated, the commercial fishing industry contributes over $28 billion a year to our economy and about $20 billion a year is spent on recreational marine fishing activities (NOAA, 2003e). More than 170,000 people and 123,000 commercial fishing vessels are employed in U.S. fisheries (NMFS, 2003e). The number of vessels greater than 5 net tons is about 23,000 (1987) with a total of 1,000,000 Gross Registered Tons (NMFS, 1996). The secondary sector (processors and wholesalers) employs 71,533 persons (2001) working in 996 plants and 2,414 wholesalers (NMFS, 2003e). These represent just some of the many benefits Americans derive from living marine resources. For example, non-consumptive uses such as diving on coral reefs and whale-watching provide additional benefits.

U.S. fisheries operate throughout the United States in coastal waters, in and beyond the U.S. Exclusive Economic Zone (EEZ), as well as in many rivers and lakes. The resulting catch combined with aquaculture production makes the United States the 5th-ranked fishing nation with 4 percent of the total landings in 2002. In 2002, finfish accounted for 86% of the total landings but only 44 percent of the value (NMFS, 2003e).

Several marine species are under stress from overexploitation, habitat degradation, or both. Over one-third of all fish stocks for which we have reliable population data are overutilized. A few populations may be in danger of extinction, and more are adversely impacted by various human activities. There are many other species for which we have little information. Various factors, both natural and human-related, affect the status of fish stocks and their environment.

The total domestic commercial landings of edible finfish and shellfish since 1950 are shown in Figure 2. Only the tonnage for each and the total value are shown. Domestic landings of all commercial fishery products reached a record high of 4.8 million metric tons (mmt) (10.5 billion pounds) in 1993 and 1994 and a value of $3.8 billion. In recent years, the values of finfish and shellfish landings have been close to equal ($1.4 Billion and $ 1.7 Billion in 2002, respectively). Alaska Pollock ranked first again in terms of weight and total revenues in 2002 (NMFS, 2003e). However, the recent average commercial and recreational yield of all U.S. fisheries resources is still only slightly more than 60 percent of our best estimate of the long-term potential yield. The gross commercial value of the change in yield if all stocks were rebuilt to their long-term potential would yield an additional $1.3 billion to the U.S. economy at the point of first sale (NMFS, 2003b).

Figure 2.



NMFS has undertaken an aggressive plan of action to improve its ability to assess more of the 932 fish stocks that are identified and referenced in federal fishery management plans. To begin implementation of this plan, titled Marine Fisheries Stock Assessment Improvement Plan (SAIP) (NMFS, 2001), the agency received an increase of $2 million in fiscal year (FY) 2001 and $15 million in fiscal year (FY) 2003 and has requested additional funding for FY 2004. NOAA Fisheries does not routinely assess the status of many of the 932 fish stocks because generally they are not targeted in fisheries and have low probability of becoming overfished. Based on a ranking system, the SAIP shows that stocks with the longest history of catches or value rank high for having the best data collection programs and the most comprehensive assessments. This ranking system shows that NMFS is prioritizing its allocated research dollars to conduct status determinations for

those species most vulnerable to overfishing. The plan also indicates that modernization of stock assessments will require significant additional staff, some of which could be filled through cooperative research programs and other partnerships. The SAIP is available at: http://www.st.nmfs.gov/st2/saip.html.

NMFS scientists are actively engaged in research to understand, protect, and restore fishery resources and the habitats on which they depend at both ecosystem and species-specific scales. These research efforts include mapping, spatial analyses, geographic information systems (GISs), and fishery and ocean habitat modeling and characterization, as well as an evaluation of ecosystem approaches focusing on spatially-explicit models and further research into trophic relationships. Additionally, with the increasing need to seek new management approaches to enhance and conserve essential fish habitat (EFH), NMFS is conducting studies on adaptive/management techniques through the identification and use of potential marine reserve areas or refugia (i.e., using areas closed to fishing activities for both recovery and research), and experiments on no-take and limited take zones and time-area closures. NMFS is also exploring the research potential of MPAs to facilitate important experiments in marine ecology and to support recommendations made by the NRC (NRC, 2001). Further, NMFS is evaluating the potential impacts of artificial reef/habitat as well as commercial and recreational fishing activities on habitat and fisheries production. In combination with evaluating these impacts, public education plays a key role in increasing public awareness and support of our living marine resources.

NMFS' research efforts incorporate the use of innovative new technologies and techniques. For example, NMFS is cooperating with other NOAA elements to enhance survey capabilities through research and development of an omnidirectional hydroacoustic system. Airborne LIDAR (Light Detection And Ranging) technology shows promise for identifying near-surface pelagic species. Underwater laserline technology is being developed to facilitate habitat characterization and species identification. Additionally, NMFS uses manned submersibles and remotely-operated vehicles to directly evaluate deepwater species and their habitat.

It is NMFS' responsibility to provide fishery managers with the information needed to make scientifically sound decisions. In order to support fishery conservation and management, NMFS scientists are actively pursuing the following areas of research.

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

Activities in this area include collecting catch and effort data, biological sampling, and developing biostatistical analyses for a variety of Fishery Management Plan (FMP) and non-FMP species of exploited fish and invertebrates. Fishery-dependent and fishery independent (i.e., resource survey) sources provide age and size samples, catch composition, and indices of relative abundance. These data are key inputs to stock assessments, fishery management regulations, and the production of status reports for living marine resources and their fisheries.

Larval sculpin. Photo: Jay Clark and Matt Wilson, AFSC.

On October 17, 2003, VT Halter Marine, Inc., and NOAA launched the first of four planned NOAA fisheries survey vessels. Christened *Oscar Dyson*, the 208 ft. ship will be one of the most technologically advanced fisheries survey vessels in the world when it enters service in the summer of 2004. Its capabilities will far exceed those of older NOAA ships. It has been built to meet very specific data collection requirements as well as to meet exacting quietness standards set by the International Council for Exploration of the Seas—to avoid disturbing the fish and mammals it is trying to study. The four ships will either augment or replace aging ships in the NOAA fleet. The second ship is under contract and scheduled for delivery in the summer of 2006. The other two ships, subject to appropriations, will follow in 2007 and 2008.

The biology and life history of species has taken on greater significance in managing the Nation's living marine resources. Describing and understanding migration and distribution patterns, habitat use, age, growth, mortality, age structure, sex ratios, reproductive biology, and responses to environmental variability are key to developing harvest strategies that produce high yields at low risk to the long-term sustainability of the resource base. A variety of scientific methods are employed, including aging using otoliths, histological analyses of gonads, food studies, and observations of spawning behavior. Studies of early life history and fishery oceanography are necessary to understand recruitment dynamics, with the aim of predicting incoming year-class strength. There is an increasing need to identify and characterize discrete stocks. The use of molecular DNA techniques, life history parameter estimates, and ecological habits can aid in determining stock boundaries. This will enable scientists to correctly structure stock assessments and design stock-specific management measures.

The complexity of any assessment is determined by the amount of available data and by the type of information required for scientific advice to fishery managers. Stock assessments can be ordered according to level of modeling effort and sophistication, each one incorporating the underlying data requirements of all preceding levels.

Assessment Levels:

- 0. No Assessment: no assessment has been done.

- 1. Index Only: a time series of relative index of stock abundance calculated as raw or standardized catch-per-unit-of-effort (CPUE) in commercial, recreational,

or survey vessel data; or a onetime estimation of absolute abundance derived from tagging results, a depletion study, or some form of calibrated survey.

- 2. Simple Life History Equilibrium Models: typically applied to life history information; for example, yield-per-recruit or spawner-per-recruit functions based on mortality, growth, and maturity schedules; catch curve analysis; survival analysis; or length-based cohort analysis.

- 3. Aggregated Production Models: data available and used as input for equilibrium and non-equilibrium production models aggregated both spatially and over age and size classes; these include the classic Schaefer model and the Pella-Tomlinson model.

- 4. Size-, Age-, Stage-Structured Models: techniques that include cohort analysis, virtual population analysis, age-structured production analysis, CAGEAN, stock synthesis, size- or age-structured Bayesian models, modified DeLury methods, and size or age-based mark-recapture models.

- 5. Ecosystem Models: assessments incorporating ecosystem considerations with spatial and seasonal analyses. Ecosystem components include one or more of the following: 1) one or more time-varying parameters, either estimated as constrained series, or driven by environmental variables; 2) multiple target species as state variables in the model; or 3) living ecosystem components other than target species included as model variables.

At a minimum, abundance indices are needed for all species to meet the intent of legislative mandates and to provide for early identification of problems. At-risk species may require the highest levels of assessments for effective management, particularly if they are managed near their maximum potential yield.

In an effort to better understand and quantify the status of NMFS stock assessment research, and to determine what needs to be done to improve it, the NMFS National Task Force for Improving Fish Stock Assessments defined three Tiers of Assessment Excellence (NMFS, 2001), which can be summarized as:

- Tier 1—Improve stock assessments using existing data

  a) for core species, conduct assessments that are more comprehensive, more thorough, more timely, better quality-controlled, and better communicated;

  b) for species of currently "unknown" status, mine existing databases of research vessel survey data and / or commercial and recreational statistics for archival information for new analyses to evaluate status determination criteria.

- Tier 2—Elevate stock assessments to new national standards of excellence

  a) upgrade assessments for core species to at least Level 3 (see above Assessment Levels), providing analytical models in which ages or species are aggregated;

b) conduct adequate baseline monitoring for all federally managed species (including rare species).

- Tier 3—Next generation assessments

a) assess all federally managed species or species groups at a minimum level of 3, and all core species at a level of 4 or 5 (size-, age-, or stage-structured models, possibly including spatial and seasonal considerations, species associations, and oceanographic effects);

b) explicitly incorporate ecosystem considerations such as multispecies interactions and environmental effects, fisheries oceanography, and spatial and seasonal analyses.

By quantifying the status of assessments for each of the important species and the amount of resources required to raise the assessment status to the next tier, NMFS has been able to determine the budgetary and other resources that are needed to improve stock assessments.

I.B. Social and economic factors affecting abundance levels

NMFS also recognizes the social, cultural, and economic diversity of fisheries, and the importance of recognizing those differences in creating effective conservation measures. For instance, one critical factor affecting stock abundance is the level of fishing effort. Type and location of both commercial and recreational fishing effort vary across different fishing fleets, groups of anglers, and communities. Also, these groups will differ in their responses to alternative strategies of effort control such as days-at-sea, closed areas, limited access, and bag-limits. NMFS will need new data and models, and modifications to existing models, to capture fully this diversity and its interaction with biological diversity.

NMFS is therefore developing biosocioeconomic models and increasing the collection of data necessary to meet conservation goals and maximize net economic and social benefits to the Nation from living marine resources. For commercial fishing, these data include: vessel and plant level cost and earnings data; ex-vessel prices; and data on social, cultural, and institutional influences such as open access regimes or differing ethnicity-based labor practices. For recreational and subsistence fishing, these data include: information on expenditures, trip characteristics, demographic descriptors, and social and cultural influences on fishing behavior. Knowledge of socioeconomic factors that may facilitate or constrain certain management regimes is essential. Given that some of these data are newly emphasized, national coordination and funding of these activities is important.

Coordinated biosocioeconomic research and analysis will add the element of human behavior to stock dynamics, thus bringing the parameters of our models closer to real world conditions. This, in turn, will improve the predictive power of stock assessments.

I.C. Interdependence of fisheries or stocks of fish

Living and nonliving parts of an ecosystem are linked to each other through physical and biological relationships—for example by food chains or shared habitat use. This information is important if we are to successfully manage our living marine resources in a holistic manner. The health of a fish stock and the merits of alternative harvest strategies cannot be determined in isolation; an ecosystem-based approach is needed to take into account the various factors that affect the status of a stock and the importance of a stock to other components of the ecosystem, as recommended in the Ecosystems Principles Advisory Panel's Report to Congress (EPAP, 1999). The abundance, productivity, and spatial distribution of a fish stock depends on a number of factors, including environmental conditions, habitat quantity and quality, the abundance and health of its competitors, predators, and prey, as well as its symbiotic relationships.

The objective of biological studies on ecosystem interdependence is to understand the functional relationships among ecosystem components. To do so requires that we determine consumption rates and the functional form of feeding interrelationships of fish as well as spatial and temporal variability in abundance and habitat use. We are developing recruitment and multispecies models that incorporate food web and environmental information. The models can be used to help predict long-term impacts of various harvest strategies and environmental trends on yield potential and species composition as well as to investigate effects of predation and compensatory population mechanisms on long-term stability, production, and structure of fish communities under different harvest strategies and environmental regimes. Research activities include:

- Marine food web research through field and laboratory studies of fish consumption rates, feeding selectivity patterns, food preference, and nutritional values of various foods.

- Density-dependent and predator-prey dynamics.

- Fisheries oceanography research to determine how environmental conditions create variability in biological components of the ecosystem.

- Food-web-based dynamic mathematical models that are used to examine how abundance of fish stocks, marine mammals, and other ecosystem components react to changes in environmental conditions and alternative fishery management measures.

Different fishing behaviors, based on use of different gear types and vessel sizes among commercial or recreational fishers, impact ecosystems differently and also have different consequences for non-consumptive user groups, for example in the availability of fish or mammals to view. These different behaviors and impacts and the different values of various ecosystem attributes by different user groups are important to ecosystem management. For example, the development of a wetland for industrial or residential purposes may impact water quality and thus require that a water treatment plant be constructed to replace the natural filtering action

of a wetland, so that an offshore coral reef is preserved. Some critical research areas include:

- The suite of fishing and non-fishing activities available to commercial and recreational fishers for which they are qualified.
- The geographic range within which various consumptive and non-consumptive user groups operate.
- The identification of all user groups, including but not limited to consumptive and non-consumptive as well as those that value the existence of the resource.
- The effect of point and non-point specific sources of pollution on the ecosystem; e.g., hypoxia in the Gulf of Mexico.
- Establishment of safe minimum standards for fishery and other resources in the ecosystems.
- Identification of the role of coastal settlements on ecosystems and stocks of fish.
- Identification of the role of ecosystems and stocks of fish on coastal settlements.
- Determination of the interactions and links between user groups and fish stocks.
- Establishment of a national biosocioeconomic panel of experts to advise NOAA and NMFS on ecosystems, habitat, fish stocks and their interdependence with all affected user groups.
- The amount and value of subsistence, recreational, and part-time fishing.

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

The long-term viability of living marine resources depends on conservation and protection of their habitat. The effects of habitat degradation are often insidious, and some losses are not well understood. Others, however, are apparent. We know, for example, that dams for hydroelectric power generation and water diversion for agriculture have severely reduced some valuable anadromous fish runs, and chemical contaminants cause neoplasm and reproductive dysfunction in fish (e.g., winter flounder in Boston Harbor and English sole in Puget Sound). We also know that habitat changes in Florida Bay and Chesapeake Bay have resulted in changes in fish communities, and that environmental perturbations, such as El Niño, change the latitudinal distribution, abundance, and recruitment dynamics of several species on the west coast. It has become apparent that many changes to the habitat are not only the result of natural processes, but also the direct result of human interactions with the environment.

The Sustainable Fisheries Act of 1996 requires fishery management councils (FMCs) to describe and identify EFH in FMPs, to minimize to the extent practicable adverse effects of fishing activities on such habitat, and to identify other actions to encourage the conservation and enhancement of such habitat. It also requires that the Secretary of Commerce initiate and maintain related research. MSFMCA defines EFH as

> "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purpose of interpreting the definition of EFH: 'waters' include aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include aquatic areas historically used by fish where appropriate; 'substrate' includes sediment, hard bottom, structures underlying the waters, and associated biological communities; 'necessary' means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; and 'spawning, breeding, feeding, or growth to maturity' covers a species' full life cycle." (Federal Register, 2002).

NMFS will continue to conduct research, analyze data, and provide consultation necessary to: 1) identify freshwater, estuarine, coastal, and oceanic habitats and their utilization by various life stages of living marine resources for spawning, growth, and reproduction, through comparative studies of similar habitats in stressed and unstressed environs as well as comparative studies of different habitats; 2) document the life history of managed fish and determine factors that influence resiliency or sensitivity to fishing; 3) increase NMFS' understanding of the role of the benthic community in the overall ecosystem, the interaction of target fish with benthic communities, and effects of fishing on benthic communities; 4) determine the best methods for restoring LMRs injured by human impacts including harmful spills, vessel groundings, material disposal, and fishing; 5) develop population and habitat recovery models; 6) describe seasonal changes in the character of the water column and seabed, megainvertebrates, and benthic infaunal communities in estuaries and nearshore waters; 7) map EFH using remote sensing platforms (satellite, aerial, and acoustic) along with ground truth and algorithm development to assess habitat type and quality and environmental parameters such as temperature, turbidity, and salinity; 8) work cooperatively with fishers to gain information on existing fishery habitats; and, 9)

Mangrove roots in the Florida Keys provide habitat for juvenile fishes. Photo: William B. Folsom, NMFS.

determine the social, cultural and economic needs of fishing communities with respect to EFH designations. Fishery managers will use the information resulting from these activities to identify, describe, conserve, and enhance EFH.

NMFS Science Centers work closely with the Regional Offices, FMCs, National Ocean Service (NOS) research facilities, the NOAA Damage Assessment and Restoration Program, other Federal and state agencies, and academic and other partners to provide timely habitat information. NMFS works with the NOAA line offices and other agencies to develop the Coastal Change Analysis Program and Coastwatch to apply satellite imagery and aerial photography to habitat mapping, analysis of change in coastal land cover, and assessment of water temperature, color, and circulation.

These research areas and the specific EFH research described for each Fishery Science Center will be used by NMFS and the FMCs to:

- Develop a comprehensive and coordinated base-funded habitat research program in NMFS that interacts with and provides information to habitat managers, the FMCs, and the Offices of Science and Technology, Sustainable Fisheries, Habitat Conservation, and Protected Resources.

- Improve understanding of the distribution and habitat requirements of early life stages of managed species and their prey and predator species.

- Improve stock assessment capabilities and reduce uncertainty.

- Improve habitat conservation, protection, and enhancement capabilities and improve assessment of threats to EFH and managed fish stocks.

- Evaluate and predict how environment and climate signals change the distribution and amount of EFH for important stocks.

- Synthesize research information needs nationally and prioritize habitat research and funding across regions to refine EFH identification, assess and minimize adverse effects of fishing activities, and identify actions to encourage the conservation and enhancement of such habitats as required by the MSFCMA.

- Develop a national database on habitat restoration measures and designs that enhance recovery of biodiversity and value to fisheries.

- Map EFH for managed species in each region, and develop a national GIS database on essential habitat.

- Provide GIS identification and mapping of habitat subject to adverse impacts from fishing gear.

- Restore degraded habitat using restoration options that have a scientific base.

- Cooperate with fishers in gathering information on habitat.

- Study incentives for habitat protection, including literature reviews of incentives for non-fishery activities such as land-based non-point-source pollution.

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

Changing conditions of the biotic and physical environment occupied by fish, whether natural or anthropogenic, affect population productivity through mechanisms ranging from sublethal to acute. Detecting such changes is an important task, but determining causal relationships is complex. Anthropogenic effects may be confounded by natural environmental changes or cycles. NMFS is conducting research to unravel these complex relationships to better understand their role in the sustainability of marine fish populations.

Toxic contaminant discharges to the coastal oceans can have a significant impact on the viability of important fish populations. For example, contaminants can disrupt an organism's early life stage development and growth, which in turn can affect their reproductive potential as adults. Such nonlethal effects are not easily identified or characterized, and therefore, are difficult to relate to the sustainability of the fish populations. The quantification and identification of deleterious changes is further complicated by natural and uncontrollable variability within and between fish populations and their supporting food webs.

NMFS will continue to study the potential effects of contaminants on important fish species as well as the sources of variability. To assess the risk to fish populations from different combinations of stressors there must be a linkage made between understanding toxic effects of contaminants to individual organisms and the factors, both anthropogenic and natural, that influence fish populations. There has been growing recognition that marine pollution can disrupt the development and function of the reproductive, endocrine, immune, and nervous systems of marine animals, including fishes, affecting reproductive and growth processes critical to population stability. Because the effects are not always immediately visible, it is difficult to establish the impact on fish populations. Environmental variation at different temporal and spatial scales further complicates the picture. NMFS will continue to study similar habitats in stressed and unstressed anadromous streams, estuarine, and ocean environs in order to understand the effects of pollution on LMRs and their habitats.

NMFS is also studying social and economic causes of habitat degradation, from fishery and non-fishery sources. This research includes coordination with researchers studying land-based activities such as non-point source pollution and urban development. NMFS also engages in research to determine the effects of long-term changes in the ocean climate on LMRs. This information helps assess the true impact of human-induced factors.

Habitat loss and degradation affects riverine, estuarine, and coastal ecosystems. The primary threats come from physical destruction of wetland and other habitats, or access to it, such as through dams, alteration of freshwater flows, eutrophication, and destructive fishing methods. For example, logging contributes to silt-

ation and can destroy salmon spawning habitat upriver and impede their migratory paths. Construction of marinas and docking facilities as well as dredging and disposal of dredged material in estuaries and bays also cause significant habitat impacts. Loss of aquatic habitat (e.g., coastal wetlands or seagrass and kelp beds) resulting from development adversely affects a variety of food webs that are important to adults and juveniles of many marine and anadromous species. Propeller damage to shallow vegetated and nonvegetated habitats not only causes a direct loss of habitat, but results in destabilization of these areas, resulting in increased habitat loss and increased sediment resuspension and turbidity. Changes in freshwater volume and flow rates impact nearshore ecosystems adapted to seasonal discharges of freshwater. Destructive fishing methods can damage EFH and coral reefs.

Nutrient enrichment and eutrophication have a major impact on fish populations in estuarine and coastal waters. This impact is manifested by hypoxia / anoxia accompanying the death of phytoplankton populations (e.g., in the Gulf of Mexico dead zone off the Mississippi River and the western Long Island Sound) and loss of inshore habitat (replacement of eelgrass beds by macroalgae or loss of eelgrass beds due to shading by epiphytes or phytoplankton in Chesapeake Bay, Waiquiot Bay, and Lake Pontchartrain). In addition, changes in nutrient dynamics can create conditions that facilitate harmful algal bloom events that may lead to wild fish kills, shellfish harvest closures, and mass mortalities of farmed salmon in the Northwest. Fishing activities could also change the population dynamics of harmful algal species. A change in trophic webs that decreases grazing on phytoplankton is a major factor in many blooms leading to more or longer lasting bloom events. The potential effect of climate change or environmental variability on harmful algal blooms events is also uncertain (or poorly known).

NMFS is engaging in a variety of research initiatives to study the effects of natural and man made environmental changes on living marine resources and the related ecosystem, social, and economic causes and effects, including:

- Examining the effects of mobile fishing gears, such as bottom trawls, which disturb the sea bottom and damage fragile corals and other benthic habitat.

- Determining the cumulative effects of watershed and regional land cover and changes in that land cover on EFH.

- Ecosystem monitoring for habitat degradation and resource surveys by satellite remote sensing and shipboard and moored instrumentation.

- Developing rationales / methodologies to detect and quantify habitat loss and gain.

- Establishing a GIS database to document and track habitat changes.

- Researching natural environmental variability at temporal and spatial scales pertinent to marine fish populations.

- Developing methodologies to detect and quantify the effects of habitat alterations on fishery populations.

- Conducting laboratory and field research to identify the probable results of contaminant inputs and habitat alterations that significantly affect important fishery species.

- Developing molecular genetic techniques to assess the fitness of fishery organisms.

- Developing models (descriptive and predictive) to assess the risk posed by contaminants and habitat alterations to fishery populations.

- Analyzing and synthesizing existing environmental and fishery data that are available on fishery habitat types and fishery populations.

- Separating the effects of natural versus human-induced climate change.

- Developing methods to identify, map, and forecast harmful algal blooms.

- Determining the effect of fishing on ecosystem trophic structure and population dynamics.

- Assessing, through cooperation with fishers, habitat changes over the past decade.

- Assessing current economic and social incentives for habitat protection or degradation.

II. Conservation Engineering Research

Conservation engineering research is intended to make fishing gear more efficient and to reduce fishing costs, bycatch mortality, and habitat destruction. It is also intended to improve the data provided by scientific surveys of fish populations. This research area includes studies related to gear performance and fish behavior to be used in the development of selective fishing gear to reduce bycatch. Bycatch is responsible for the death of millions of juvenile finfish, including red drum, red snapper, weakfish, Spanish mackerel, and king mackerel. For example, prior to the implementation of bycatch reduction devices (BRDs), it was estimated that between 15 to 50 million red snapper were annually taken and discarded in the offshore shrimp fishery in the Gulf of Mexico. The Food and Agriculture Organization (FAO) estimates that one-third of the world's 16 billion lbs. of bycatch comes from shrimp fishing. Although new analyses are pending since the introduction of BRDs, the most recent studies of bycatch estimate that the ratio of bycatch to shrimp landed is 5.25:1 in the Gulf of Mexico (GSAFDF, 1997). The worldwide bycatch ratio for all fisheries is 0.35 lb. to 1 lb. of target species (Alverson et al., 1994).

A loggerhead turtle escaping from a turtle excluder device in the Gulf of Mexico. Photo: Ian Workman, NMFS.

Since few discarded fish from trawls survive, bycatch constitutes a problem for fishery managers because it represents both an unaccounted mortality in fisheries and an economic loss to harvesters and the Nation. For instance, fishers in another fishery might target the discarded species, or fishers in the same fishery might be able to keep and market those same fish if they were older or larger. Recreational discards are another source of fishing mortality. Information is needed to determine proportions of discards in different recreational fisheries and assess associated release mortality. Additionally, NMFS is encouraging research on ways to increase the survival of recreational releases. Bycatch reduction, then, is critical for the continued existence of healthy fisheries, and is particularly critical when the bycatch includes protected species. Additionally, NMFS conducts research at several of its laboratories on populations of ESA-listed species and marine mammals. Stocks of listed species and marine mammals interact with species managed under the MSFCMA (e.g., competition for food, bycatch). As such, research conducted to support requirements of the MSFCMA also make an important contribution to the conservation and management requirements of the ESA and the MMPA. Along with incentives and other management strategies, one solution to bycatch reduction is to design and operate selective fishing gears, using knowledge of species behavior, gear hydrodynamics, and fishing practices.

An important data collection method used by NMFS to conduct research on fishing gear and its impact on fish stocks, protected species, and habitat, is the deployment of marine resource observers on commercial and recreational fishing vessels. Observers collect information on all aspects of fishing gear operations, including what kind of gear is used, how it is set, how long it is set, and how it is retrieved, as well as information on fish catch and bycatch and incidental takes of protected species. Observers also collect life history data on species of concern, collect biological samples, and support research through tagging of released animals and other activities. Observer data provide information for stock assessment research, for the assessment of gear efficiency, and for monitoring the relative impacts of various types of gear and fishing methods on fish and protected species and marine habitats. Currently, observers are deployed in only a fraction of the U.S. commercial and recreational fisheries managed by NMFS or required to be monitored under the MMPA, but there are initiatives underway to expand the observer program into more fisheries and to more fully integrate observers into fisheries research activities.

Bycatch levels and control measures continue to occupy the attention of most fishery management actions of the regional FMCs. Even when apparent solutions are found, the dynamics and abundance of marine species change in time and

area, and this can shift the character of the problems and require continuous adjustments to their solutions. NMFS will continue to conduct studies to determine the magnitude of bycatch of overfished stocks and options to reduce it. The options may require the design of new types of fishing gear that are more selective for the targeted species. This approach is known as "conservation engineering" and NMFS is working in cooperation with the fishing industry and gear manufacturers to find designs that meet conservation needs while recognizing the financial constraints of fishers.

To determine when gear modifications are the most appropriate response to bycatch problems, NMFS is studying existing programs such as the turtle excluder devices (TEDs) in the Gulf of Mexico and BRDs to exclude finfish from Gulf shrimp trawls and from northern shrimp trawls in New England. By understanding the successes and setbacks in these and other settings, NMFS will be better able to coordinate gear research with the social, economic, and institutional constraints of specific fisheries.

Experimental work with selective fishing gear involves considerable field work on board fishing vessels working under actual fishing conditions. Most trawl gear evaluation includes an alternative tow approach, varying which net is fishing with the experimental gear and comparing the catch results using statistical tests. Underwater cameras allow for examination of the behavioral mechanisms and gear variations that would account for the catch differences.

Growing controversy over the impact fishing gear is having on EFH has resulted in a need to evaluate the impacts. Effects from fishing may include physical disturbance of the substrate, and loss of and injury to, benthic organisms, prey species and their habitat, and other components of the ecosystem. Experiments are being designed to assess the potential effects of all fishing gear types used in waters described as EFH. These studies will include the use of remote underwater cameras, divers, abundance studies, and perhaps research closure areas for comparison. If an adverse effect is identified and determined to be an impediment to reaching target long-term production levels, then the research needed to quantify and mitigate that effect would be the next logical step.

Growing concern over the impacts of bycatch on stocks has resulted in the development of a NMFS Bycatch Plan (NMFS, 1998a). Agency experts with experience in fishery management, stock assessment, and social sciences compiled this plan. It includes proposed national bycatch objectives, specific recommendations concerning data collection, evaluation and management actions necessary to attain the objectives, and a comprehensive assessment of the state of bycatch in the Nation's marine fisheries. The latter is intended to serve as a benchmark from which progress in bycatch reduction can be measured.

NMFS is committed to maximizing the research contribution of the fishing industry and other nongovernment participants in the fisheries. Across the NMFS regions, the industry is providing advice in research planning, in formal reviews of research programs, and, where possible, in research operations. Examples of research involvement include: 1) provision of expertise, ideas, chartered vessels and

crew for surveys and bycatch gear development; 2) keeping logbooks of species catches, including bycatch; and 3) industry efforts to develop gear, gear modifications, and fishing practices to reduce bycatch.

The Saltonstall-Kennedy Grant Program has had direct industry involvement and investment since its inception decades ago. Industry members submit proposals, usually with considerable cost sharing, to conduct research in conservation engineering, to develop fisheries for underutilized species to relieve pressure on traditional species, and to improve the after-catch utilization of captured species.

III. Research on the Fisheries

The condition of the fish stocks upon which the U.S. fisheries depend is steadily improving. New management measures, based on the Sustainable Fisheries Act (Public Law 104-297), have been successfully implemented to halt the decline in stock levels in many U.S. fisheries.

The 2002 annual report to Congress on the status of the U.S. fisheries is the sixth annual report of its kind. It identifies 932 marine fish stocks in the EEZ, an area that extends from 3 to 200 miles offshore and covers more than 2 million square miles, including those stocks that straddle international boundaries and highly migratory stocks (NMFS, 2003c).

Of the 658 stocks whose overfishing status is currently unknown, only 89 stocks or 14 percent are characterized as major; of the 274 stocks whose overfishing status is known, 170 stocks, or 62 percent, are major stocks. Major stocks accounted for approximately 99 percent of the landings in 2001. While minor stocks are important in an ecosystem context, these stocks have not merited the same level of priority given to stocks that are actively harvested (NMFS, 2003c).

Rebuilding programs are approved or are under development for most of the 86 overfished stocks. In 2002, the total number of approved programs stood at 75, including 33 rebuilding programs currently in place for major overfished stocks and 37 for minor overfished stocks. An additional four programs have been approved for major stocks that are not overfished but must continue to rebuild to the average level associated with maximum sustainable yield, and one major stock has an undefined rebuilding target. In some cases, particularly Atlantic highly migratory species, rebuilding programs have been approved, but not yet implemented pending adoption of an international rebuilding regime (NMFS, 2003c).

Excess fishing capacity or “overcapacity” remains a concern in certain U.S. fisheries and occurs when the ability to catch fish exceeds what is needed to harvest the amount of available fish. A recent study of a number of federally managed fisheries reports that 55 percent of the assessed fisheries have some measurable overcapacity, 29 percent do not, and information is lacking for the remaining 16 percent. In some regions, vessels and fishing permits are being bought and retired as part of Federal buy-back programs (NMFS, 2003a).

III.A. Social and economic research

A commercial fishing vessel out of Dutch Harbor, Alaska. Photo: Allen Shimada, NMFS.

Social and economic information has become increasingly important in addressing fishery conservation and management issues. Federal law, Executive Orders, and NMFS policy require social and economic assessments of proposed regulatory or policy changes. The U.S. fishing industry, however, is quite diverse. Competition within and between consumptive users of living marine resources, such as commercial and recreational fishers, and non-consumptive users, who value the existence of living marine resources, greatly complicates the resource allocation decisions fishery managers face. Significant diversity exists between firms within the commercial fishery, and can be seen by the variation in the sizes and types of vessels between fisheries as well as between geographic areas. In addition, oftentimes no clear distinction in an actual fishery exists between commercial fishing firms and individual recreational fishers. Instead, a continuum of activities separate two extreme forms of fisheries exploitation including recreational fishers who sell their catch, headboat and charterboat operations, meat fishers, and catch-and-release fishers. Equally important are individuals who value knowing a particular fish species exists or value the existence of species dependent on a fish stock or stocks; e.g., whales, Steller sea lions, and marine turtles. One consequence of the size and diversity of the users of living marine resources is that the goal of managing U.S. fisheries to maximize the net present value of benefits to the Nation is difficult to achieve.

The application of this broad-based policy to individual fisheries is difficult because each fishery has unique biological, economic, and sociological characteristics that require different types of regulatory approaches. For example, vessel sizes, gear types, crew sizes, and processing, marketing, and distributional arrangements vary significantly among fisheries and geographic areas. Educational levels, household dependence on fishing, preferred target species, and fishing patterns differ across fisheries and fishing communities. Levels and types of social, cultural, and economic dependence on fisheries vary by community and region.

Management decisions must reflect the values as well as needs of many different groups, including commercial and recreational fishers, subsistence fishing communities, non-consumptive users, Pacific Islanders, and Native American tribes (many of which have treaties with the United States guaranteeing certain fishing rights). It is important to identify the demographic, sociological, and anthropological characteristics of the different user groups and how they value fishery resources, including the differences between groups.

Management by NMFS must be done within an economic framework that considers economic efficiency and provides equity or fairness to all resource users. This economic framework considers the transition time associated with a proposed regulation to minimize adverse economic impacts on fishing dependent communities, firms, and individuals. Adequate consideration of these factors requires that NMFS collect and analyze sufficient information about fishing communities, commercial and recreational fishing firms or individuals, and other consumptive and non-consumptive users of our living marine resources. Without sufficient data and analyses, we will have inadequate social and economic assessments and will be unable to determine if our management policies are achieving their intended objectives.

To examine human activities in an ecosystem perspective, research is required on the behavior of consumptive (e.g., commercial and recreational fisheries) and non-consumptive (e.g., whale watchers and non-harvest divers) users of the resource. Some fishers target a single species or species assemblage exclusively. Others fish for a variety of different species by season (an annual round), sometimes switching fishing gears to do so. Yet other fishers are part-time participants only, working in land-based occupations for some portion of the year. Other users of the ecosystem who, for example, swim with sharks or view coral reef communities benefit from a rich and diverse habitat. Still others who never see the resource value knowing that it exists and that it is being conserved for their children, grandchildren, and future generations.

To produce high quality assessments will require new data and models on a number of sectors, including the following:

- The U.S. commercial harvesting sector: Detailed social and economic analyses of the majority of U.S. fisheries is being conducted in conjunction with stock assessments to determine current social and economic costs and benefits in the harvest of living marine resources, and to determine methods to maximize net benefits through innovative management alternatives.

- The U.S. recreational harvesting sector: The recreational and commercial fishing sectors are interdependent and have much in common. Policies aimed at regulating one group almost always impact the other and often affect other sectors of the marine fishing industry. NMFS will assess the net economic and social benefits from various allocation scenarios using demographic, social and cultural information, estimates of anglers' consumer surplus, commercial fishers' producer surplus, and, theoretically, the consumer surplus for commercial catch as well.

- Fishing communities: NMFS is collecting or acquiring from other sources qualitative and quantitative ethnographic, demographic, and economic data important for the social and economic and cultural profiling of fishing communities, including opportunity costs, social structure, and ethnohistorical data, and other data needed for the estimation of net benefits for use in input-output models to determine social, cultural, and economic effects of alternative management strategies.

- **Non-consumptive users:** NMFS is collecting information necessary to understand the economic and aesthetic value of living resources to non-consumptive users. For example, this includes people who enjoy whale watching, swimming on a coral reef teeming with colorful fish, or simply knowing that there are still fish in the sea. There are cultural and economic impacts of these activities that are just beginning to be understood.

- **The U.S. subsistence and traditional use fisheries:** NMFS is collecting data to support empirical research using both qualitative and quantitative techniques of fisheries economics, anthropology and sociology, including alternative sources of protein and cultural and ritual uses of the harvested living marine resources, to model and assess social, cultural, and economic factors related to community dependence on the fishery.

- **The U.S. seafood processing / wholesale sector:** The processing and wholesale sectors are an integral part of the seafood industry. As in the harvesting sector, technological innovations advance the processing and distribution of seafood. NMFS will continue to collect annual data to determine the total number of processing and wholesaling plants, the number of people employed, and the total volume and value processed. NMFS will also increase data collection to support research on social and economic relationships among fishing firms, processors, and wholesalers to better understand the cultural and other institutional influences on the structure of seafood markets (e.g., to develop econometric models of the processing sector to determine the effect of common property resources on capital investment).

- **The U.S. trade sector:** The U.S. plays a major role in the international seafood market, importing and exporting billions of dollars worth of seafood each year. The U.S. seafood trade market in part determines conditions in its domestic fisheries. NMFS conducts an annual survey to determine our share of the international seafood trade market from which econometric analyses of supply and demand conditions in international markets can be developed to determine how trade agreements impact our Nation's competitiveness in this arena.

- **Retail demand for seafood:** Social and economic forces in the United States over time have influenced the current makeup of seafood distribution, marketing, and consumption. Population, real per capita income, and the prices of substitutes are three factors that economic theory suggests should explain the aggregate demand for seafood. NMFS is conducting studies to gain a greater understanding of the responsiveness of consumers to changes in prices, quantities, and product quality, their willingness to substitute among various seafood products and other protein sources, their readiness to purchase imported products, the responsiveness of fish and fishery product prices to changes in harvest levels, and the influence of social and cultural factors.

- **Economic impact analyses:** NMFS will continue to collect economic data to meet the requirements of Executive Order 12866, the National Environmental Policy Act, regulatory flexibility analyses (RFAs), and fishery impact statements for the MSFCMA.

Aquaculture facility. Photo: NWFSC.

- **Social impact assessment (SIA):** NMFS will continue to collect ethnographic, economic, and biological data related to fishing decision-making processes of captains; investment decision-making processes of owners; information flows within the fishery; and the differential effects of management policies on various subsets of the fishing industry such as absentee owners, captain-owners, and crew members, full-time and part-time fishers, fishers with different household compositions, large vessels and the undertonnage fleet, those who target single species or complexes, and those who fish different gears and species by season.

- **Overcapacity:** NMFS will continue to assess current levels of capacity of U.S. commercial and recreational fishing fleets (i.e., charter/party vessels), determine optimal levels, and develop approaches to solving the problem of overcapacity.

- **Fisheries management:** NMFS will continue to seek to integrate the existing biological, economic, and other social sciences information into a single biosocioeconomic framework, or model, from which information can be generated to aid fishery managers in making decisions about our living marine resources.

III.B. Seafood safety research

Intra- and extramural seafood safety research is aimed at continuing the integration of trophodynamic investigations relative to fishery resource health and disease threats, and differential trophic level risk evaluation effects resulting from such threats, be they to other fishery resources, marine mammals, or human consumers. Studies are focused on identifying and determining the characteristics of marine pathogens; improving methods to detect, forecast, and evaluate the ecological significance of harmful algal blooms; as well as developing and applying biological and chemical analytical methods to measure toxic contaminants to restore living marine resources and their habitats. Additionally, when needed, specific highly focused research is rapidly directed to address crisis situations dealing with animal and human health concerns, such as that needed to perform a Risk Assessment to wild shrimp stocks resulting from imported aquaculture shrimp products being infected with various shrimp viruses or reevaluating the human exposure rate from mercury in seafood. These research efforts are conducted primarily at the National Seafood Inspection Laboratory in Pascagoula, MS, as well as at the Northwest and Southeast Fisheries Science Centers.

III.C. Marine aquaculture

The importance of marine aquaculture (mariculture), both in the U.S. and throughout the world, is widely recognized. The production limits of wild stocks are being reached, and most of the increased global production of fisheries products for the last decade has come from aquaculture. In many countries aquaculture is progressing more rapidly than in the U.S., and one-third of the global supply of food fish now comes from aquaculture (FAO, 2003). The annual U.S. trade deficit in edible fishery products is about $7 billion. U.S. aquaculture production in 2001 was about 820,000 pounds (373,000 metric tons) with a value of $935 million. About one-third of this is from marine species. Based on estimated production data, aquaculture probably accounts for more than 25% of the total U.S. landings value. There is significant potential to increase U.S. marine aquaculture production. However, there are technical, environmental, and socioeconomic issues that need to be addressed through basic and applied research and through an examination of policies. These issues include disease transmission, wild forage fish used for feed, escapees breeding with wild fish and eroding genetic diversity, market place competition with wild products, and competition for food and space with wild stocks. NMFS has scientific expertise that can be applied to all of these issues. NMFS has had a long history in aquaculture research and development, stretching back more than 100 years, and has made major contributions to the progress of aquaculture both domestically and internationally. Also, NMFS has environmental stewardship responsibilities and the expertise to assess the appropriate role of mariculture and its potential impacts on wild stocks and habitat quality. Finally, NMFS has responsibilities for permitting aquaculture projects, and it is important to use good science as a basis for establishing clear policies for permitting decisions.

Over the last several years there has been slow but continuous growth in domestic aquaculture production and strong growth in the amount of aquaculture products imported into the U.S. Probably the chief reason for these increases has been the decline in prices for both domestically produced and imported products. From 1999 to 2001, catfish production has been relatively flat while there has been a 10-percent decline in the average price over the last 4 years. Salmon and shrimp imports have risen rapidly while the average price of those imports was falling sharply. The domestic industry is expected to face continuing strong competition from imports and from the domestic poultry and livestock industries, with increased production and lower prices forecast in these sectors (USDA, 2002).

In addition to food production, aquaculture can also play a role in enhancing wild stock populations, assisting in recovery plans for protected species, and can be used to produce nonfood products such as ornamental fish, baitfish, and pharmaceuticals. Expanded mariculture production in the United States has the potential to reduce the pressure on wild stock harvest and help in the rebuilding efforts for those stocks.

Three U.S. Government Departments, Agriculture (USDA), Commerce (DOC), and Interior (USDI), and several of their agencies share aquaculture responsibilities. Their work is coordinated through the Joint Subcommittee on Aquaculture

(JSA). USDA focuses on freshwater species but provides general support to all farming businesses. USDI focuses on freshwater species particularly in operating a national system of hatcheries and in assisting American Indian tribal aquaculture. DOC focuses on marine species and working with the fishery management councils, regulates the development of aquaculture in the EEZ.

There is no single federal agency for assistance to, nor regulation of, the aquaculture industry in the United States. Each facet comes under the jurisdiction of an appropriate authority, such as seafood inspection, environmental protection, food safety, technology or research assistance, licensing, and taxation, just as would other sectors of the U.S. economy.

To ensure that mariculture progresses in an environmentally sound manner, NMFS will concentrate its mariculture research activities in the following broad areas:

- Develop and evaluate commercially viable husbandry technologies for new candidate species.

- Conduct research on the effects of marine aquaculture on habitat and ecosystems, including the removal of forage species as aquaculture feed.

- Evaluate the risk to wild stocks from the introduction of cultured stocks, including determining genetic baselines of wild populations as part of the introduction decision process.

- Establish, with the help of stakeholders, uniform requirements for aquaculture development in the U.S. EEZ under a Code of Conduct for its implementation.

- Develop effective enhancement strategies for aquatic species to help in the recovery of wild stock fisheries and endangered species.

- Integrate aquaculture development with the management of wild stocks, particularly threatened and endangered species.

- Develop environmentally safe protocols for disease prevention.

- Assess the effectiveness of aquaculture as an alternative employment source for fishers in overexploited fisheries.

- Accelerate industrial implementation of aquaculture technologies through demonstration, training, and extension projects for producers, tribes, and community groups.

- Encourage coordination and collaboration of stakeholders to achieve regional and national goals by establishing frameworks for regional cooperation among the private and public sectors.

- Assist associations of producers to prepare best management practices for their respective industries with scientific analysis and assessment of risk.

IV. Information Management Research

Title IV (Fishery Monitoring and Research) Section 401 (Registration and Information Management) of the MSFCMA required the Secretary of Commerce to deliver a proposal to Congress that recommended an implementation strategy for the creation of a "...standardized fishing vessel registration and fisheries information system." This report was completed and delivered to Congress in December 1998, and outlined an approach that integrated all fisheries information required under all applicable NMFS statutory and regulatory requirements, including but not limited to MSFCMA, the MMPA, the ESA, and the Atlantic Coastal Fisheries Cooperative Management Act (NMFS, 1998b). It also includes all data collected under state authority for those states willing to participate. This report was developed in consultation with the U.S. Coast Guard, the states, the regional FMCs, the interstate Marine Fisheries Commissions, other key governmental and non-governmental organizations, and interested stakeholders. Drafts of the proposal were published in the Federal Register for public comment.

The current development of the fisheries information system is based on integrating data collection and data management systems required by NMFS, and linking them with existing state / Federal cooperative statistics programs around the country (i.e., the Atlantic Coast Cooperative Statistics Program (ACCSP); Gulf coast (GulfFIN); Pacific coast (Pacific RecFIN and PacFIN); Hawaii and Pacific islands (WestPacFin); and Alaska (AkFIN)). Linking regional systems will identify and satisfy mutual information needs for states and the Federal government. In addition, gaps in information needs not yet met by these programs will be identified through consultation with industry and policy makers.

NMFS has identified four areas to concentrate its development efforts:

- Core elements for permits and the electronic submission of information.

- Software programs for reconciling commercial landings and logbook information.

- Electronic reporting by fishermen and dealers.

- The integration of systems including standardization of metadata, documentation, and data migration.

MAJOR FISHERY RESEARCH GOALS AND OBJECTIVES

The major fishery research goals of NMFS have a one-to-one correspondence with the program areas identified in the MSFCMA except that a fifth element has been added to help focus efforts on building partnerships. All Federal agencies operate in an environment of increasing demands competing for limited resources. To meet this challenge, NMFS is increasing its collaborative efforts with other NOAA line offices and their programs (e.g., Sea Grant, National Undersea Research Program, Coastal Ocean Program), other Federal, state and local agencies, universities, Native American tribes, Pacific Islanders, the commercial and recreational fishing industries, environmental groups, and international organizations. NMFS is committed to strengthening existing relationships and building new ones.

Strategic planning usually includes the use of timetables for performance of the various activities associated with each goal. Fisheries research has been developing for over a century. Initially, it was largely comprised of studies of fundamental life history and exploratory fishing. Routine surveys accelerated with the advent of international conservation treaties and became nationwide with the passage of the MSFCMA. Much of the research is operational in nature and will continue into the future. Issues are ever-changing, as natural and human-induced changes to ecosystems modify species distributions and abundance, marketplace preferences change, and harvesting technology evolves. For example, stock assessment surveys, the analysis of the obtained data, and the projections of future abundance, are done, when there is sufficient funding, according to a schedule. Other parts of this plan involve improvements to the science or the provision of new facilities. Where such schedules have been developed, they are provided. However, most activities go on indefinitely as the issues being addressed change. Information on whether an activity is ongoing or has a defined completion date is primarily provided in this section.

The objectives under each goal have been developed through many discussions with agency managers and staff and with stakeholders and reviewers. They generally correspond to the principal functions necessary to develop and disseminate information and advice for use by fisheries managers. They also correspond to strategies in the NFSP. To facilitate cross-reference, the corresponding NFSP strategy follows each fishery research objective below.

GOAL 1: Provide scientifically sound information and data to support fishery conservation and management. (The scope centers on factors affecting the abundance and availability of resources.)

Objective 1.1: Periodically assess stocks to ascertain whether changes in their status due to natural or human-related causes have occurred. These stock assess-

ments require adequate fishery monitoring and resource surveys. Ongoing. (NFSP Assess and Predict: Implement SAIPs)

Objective 1.2: Use stock assessments to predict future trends in stock status. Forecasts will take into account projected biological productivity, climatic information, and economic and other social forces that will affect levels of fishing effort. Ongoing. (NFSP Assess and Predict: Implement SAIPs)

Objective 1.3: Determine and reduce the level of uncertainty associated with stock assessments through improved data collection and advanced analytical techniques. Ongoing. (NFSP Assess and Predict: Implement SAIPs)

Objective 1.4: Develop implementation strategy and annual operational plans for executing the days-at-sea requirements identified in the NMFS Data Acquisition Plan (NMFS, 1998c). Ongoing. (NFSP Assess and Predict: Implement SAIPs)

Objective 1.5: Use stock assessment workshops, peer reviews, and other fora to ensure that our information and advice are developed through an open and collaborative process. Ongoing. (NFSP Assess and Predict: Implement SAIPs)

Objective 1.6: Communicate our scientific information and advice, along with the associated uncertainties, to the Councils, other management authorities, and the public. Ongoing. (NFSP Engage, Advise, and Inform)

Objective 1.7: Collaborate with the Councils and other management authorities to explore and develop fishery management regimes and alternative governance systems that will effectively control exploitation and promote sustainability. Ongoing. (NFSP Engage, Advise, and Inform)

Objective 1.8: Provide guidelines to assist the Councils in assessing and specifying Maximum Sustainable Yield (MSY) for managed fisheries. Ongoing. (NFSP Engage, Advise, and Inform)

Objective 1.9: Work with the Councils to develop objective and measurable criteria for each managed stock to determine if the stock is overfished or approaching an overfished condition. Ongoing. (NFSP Engage, Advise, and Inform)

Objective 1.10: For each stock which is overfished or approaching an overfished condition, we will develop, in collaboration with the Councils, measures to eliminate or prevent the overfishing. Ongoing. (NFSP Engage, Advise, and Inform)

Objective 1.11: Conduct additional research to provide needed information to refine initial EFH designations and to help the Councils minimize the adverse effects of fishing on EFH, as mandated by the SFA. (NFSP Understand and Describe: Habitat)

Objective 1.12: Establish an inventory of living marine resource habitats (tied to *Our Living Oceans* series (NMFS, 1999)) and implement measures to monitor

the trends in habitat availability. To be published in 2004. (NFSP Monitor and Observe: Habitat Assessments / Restoration Monitoring)

Objective 1.13: Support recommendations provided by the NRC (NRC, 1999) and the Report to Congress (EPAP, 1999) by establishing criteria to define and delineate marine, estuarine, and riverine ecosystems for management purposes, and identify indicators for assessing the status and detecting changes in the health of such ecosystems. Ongoing. (NFSP Monitor and Observe: Habitat Assessments / Restoration Monitoring)

Objective 1.14: Define the key aspects of vital habitat functions and increase our understanding of how they affect marine and anadromous species and how they are affected by human activities. This will involve the development of new methods of evaluating the quality and productivity of restored habitats, as well as improved restoration and creation technologies, including contaminant remediation, to ensure that created habitats are beneficial to fish populations. Ongoing. (NFSP Understand and Describe: Habitat)

Objective 1.15: Incorporate assessments or indices of climate variability into stock assessments. Ongoing. (NFSP Assess and Predict: Ecosystem Modeling)

Objective 1.16: Monitor climate change on interannual, decadal, and centennial scales and its impact on currently sustainable fisheries. Ongoing. (NFSP Assess and Predict: Ecosystem Modeling)

Objective 1.17: Use economic and sociocultural research to predict future trends (e.g., entry and exit behavior from industry or community, organizational structure, cultural changes, etc.) of shoreside fishing-related households and firms in fishing communities. Ongoing. (NFSP Understand and Describe: Economics & Social Sciences)

Objective 1.18: Use economic and sociocultural research to predict future trends in entry and exit of fishermen to the fishery and to assess fishing capacity. Ongoing. (NFSP Understand and Describe: Economics & Social Sciences)

Objective 1.19: Conduct economic analyses of at-sea behavior to improve current and future estimates of fishery harvest and bycatch. Ongoing. (NFSP Understand and Describe: Economics & Social Sciences)

GOAL 2: Through conservation engineering research contribute to efforts to reduce bycatch and adverse effects on EFH, promote efficient harvest of target species, and improve the data from fishery surveys.

Objective 2.1: Identify and assess the magnitude of incidental takes of protected marine species. Ongoing. (NFSP Monitor and Observe: Observers)

Objective 2.2: Establish sustainable levels of takes for all protected marine species

Steller sea lions in Southeast Alaska. Photo: David Withrow, AFSC.

and continue to improve the estimates of these levels through ecological research. Ongoing. (NFSP Assess and Predict: Ecosystem Modeling)

Objective 2.3: Work through domestic and international cooperative relationships with industry and environmental groups, including take reduction teams, special task forces, and other needed scientific collaborations. Ongoing. (NFSP Cross-Cut Priorities: International Cooperation and Collaboration)

Objective 2.4: Explore, develop, and implement new technologies and practices for reducing detrimental interactions. When such technologies could reduce detrimental effects both to and from protected species in other nations these technologies will be made available to those nations. Ongoing. (NFSP Manage: Bycatch Reduction)

Objective 2.5: Establish a standardized reporting methodology to assess the amount and type of bycatch occurring in each fishery covered by an FMP. Ongoing. (NFSP Monitor and Observe: Fisheries Information System)

Objective 2.6: Work in cooperation with the fishing industry and gear manufacturers to improve gear selectivity, design and field test new gear designs and modifications, and evaluate gear regulations. Ongoing. (NFSP Manage: Bycatch Reduction)

GOAL 3: Through economic and ecological research on marine communities and ecosystems, provide scientific data and information to increase long-term economic and social benefits to the Nation from living marine resources. (The scope centers on information about how the resources are used and its integration with information about the resources addressed in Goal 1).

Objective 3.1: For each fishery management plan, collect complete suite of economic data for commercial harvesters (variable cost, annual operating cost and revenue) and recreational anglers (expenditures on fishing boat, tackle and other trip-related expenses). Ongoing. (NFSP Monitor & Observe: Economics & Social Sciences)

Objective 3.2: For each coastal state and territory, collect economic and sociocultural data needed for analyzing and understanding fishing, fishing-related industries, and fishing communities. Ongoing. (NFSP Monitor & Observe: Economics & Social Sciences)

Objective 3.3: Establish an inventory of non-market values for protected species,

essential fish habitats, and ecosystems. Ongoing. (NFSP Monitor & Observe: Economics & Social Sciences)

Objective 3.4: Determine the costs and benefits as well as the economic and sociocultural impacts to fishery participants, shoreside firms, and fishing communities from proposed management options prior to the management decision. Ongoing. (NFSP Understand and Describe: Economics & Social Sciences)

Objective 3.5: Collect data and develop integrated biosocioeconomic models to assess the net benefits to the Nation derived from living marine resources accruing to those actively engaging in fishing-related activities, e.g., commercial harvesters, recreational users, fishing communities, and seafood consumers. Ongoing. (NFSP Monitor and Observe: Social Science); NFSP Understand and Describe: Economics & Social Sciences)

Objective 3.6: Assess the non-market value of living marine resources to the Nation. Ongoing. (NFSP Understand and Describe: Economics & Social Sciences)

Objective 3.7: Assist the Councils in reviewing optimum yield (OY) levels for consistency with economic theory and with the revised definition in the Sustainable Fisheries Act. Ongoing. (NFSP Monitor and Observe: Social Science)

Objective 3.8: Study new candidate species for culture through their complete life cycle to determine which are economically and biologically suitable for commercial culture or wild stock enhancement. Ongoing. (NFSP Manage: Aquaculture)

Objective 3.9: Determine the bioeconomic requirements for the siting of aquaculture operations in the U.S. EEZ. Ongoing. (NFSP Manage: Aquaculture)

Objective 3.10: Work with the aquaculture industry to develop, identify, evaluate, and transfer technologies that are appropriate to both economically efficient aquaculture production and environmental protection. Ongoing. (NFSP Manage: Aquaculture)

Objective 3.11: Evaluate the impacts of climate change on biological, social, and economic conditions in fishing communities and commercial and recreational sectors. Ongoing. (NFSP Assess and Predict: Ecosystem Modeling)

GOAL 4: Improve the fishery information system.

Objective 4.1: Develop implementation strategy and annual operational plans for creation of a national fisheries information system as described in the December 1998 Report to Congress (NMFS, 1998b). Ongoing. (NFSP Monitor and Observe: Fisheries Information System)

GOAL 5: Improve the effectiveness of external partnerships with fishers, managers, scientists, conservationists, and other interested groups

Objective 5.1: Promote a cooperative network of partners in the coordination of fisheries research. Ongoing. (NFSP Monitor and Observe: Industry Partnerships)

Objective 5.2: Develop infrastructure for long-term, continuous working relationships with partners to address fisheries research issues. Ongoing. (NFSP Monitor and Observe: Industry Partnerships)

Objective 5.3: Sponsor symposia and conferences for partners to exchange information and identify major fisheries research initiatives. Ongoing. (NFSP Monitor and Observe: Industry Partnerships)

Objective 5.4: Solicit partners' views on fisheries research needs. Ongoing. (NFSP Monitor and Observe: Industry Partnerships)

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 NMFS Science Centers.

Alaska Fisheries Science Center (AFSC)

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 Resource Assessment and Conservation Engineering Division (RACE), the Resource Ecology and Fisheries Management Division (REFM), the National Marine Mammal Laboratory (NMML), the Auke Bay Laboratory (ABL), and other administrative units. The major shipboard platforms supporting the AFSC include the NOAA fishery survey vessels *Miller Freeman* and *John N. Cobb*, as well as chartered vessels from the fishing industry. The new fishery survey vessel, NOAA Ship *Oscar Dyson*, will be commissioned in the fall of 2004. Homeport for the *Oscar Dyson* will be Kodiak, AK; the first research cruise will take place in February 2005.

The Center has numerous ongoing relationships with external cooperators, including 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 365 employees in support of fisheries and marine mammal research in the coastal and offshore waters of Alaska. This marine region of nearly 3 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 also host to some of the world's largest populations of marine mammals and seabirds.

The Center focuses research on the following fishery resources that support major commercial fisheries off Alaska:

- Groundfish in the Bering Sea-Aleutian Islands (BSAI) region including sepa-

The Alaska Fisheries Science Center.

rate catch quotas for 14 individual species or stocks and 4 species complexes. These management complexes include: shortraker / rougheye rockfish, other flatfish (15 species), other rockfish (8 species, including thornyheads), and squid.

- Groundfish in the Gulf of Alaska (GOA) region including separate catch quotas for 11 individual species or stocks and 6 species complexes. The management complexes include: shortraker / rougheye rockfish, deep water flatfish, shallow water flatfish, other slope rockfish, pelagic shelf rockfish, and demersal shelf rockfish.

- The remaining groundfish species managed as separate "other species" groups in the BSAI and GOA regions. These management groups include species of sculpin, skate, shark and octopuses. Eight species of skate, over 50 species of sculpins, 3 species of sharks and 4 species of octopus are occasionally caught in groundfish fisheries. Commercial and scientific interest in these species is growing, while research efforts are underway to improve our knowledge of their life history, abundance, and interactions with commercial fisheries.

- Shellfish including king, tanner, snow, and hybrid crabs, several species of shrimps and sea snails.

- The five major Pacific salmon species (chinook, chum, sockeye, pink and coho) and steelhead that have supported strong traditional salmon fisheries along the entire Alaskan coastline.

In addition to research on fishery resources, the Center has recently initiated new studies that will help predict how marine resources respond to climate change, the nature and location of habitat resources required by commercially valuable fish species, and habitat interactions between fish and marine mammals. Direct research on marine mammals includes stock assessments for most marine mammal species of Alaska, as required by the MMPA and for those species also listed under the ESA. This information, in turn, is used to assess anthropogenic impacts, including direct (e.g., incidental take) and indirect effects (e.g., competition) of fisheries on those populations.

The Center also conducts research on habitat use by FMP-managed fish and invertebrates, alterations in habitat quality through human and environmental change, and an understanding of threats to habitat in Alaska. Studies involve diverse fish habitats that range from eelgrass beds to benthic substrates, and wetlands to coral and sponge communities which serve as refugia, forage grounds, or nursery areas for managed species. Perturbations include fishing, oil transportation, logging, and development, plus natural effects on fish habitat such as climate, prey distribution and nutritional quality.

RECENT ACCOMPLISHMENTS AND RESEARCH PRIORITIES FOR FY 2004–2009

I. Research to Support Fishery Conservation and Management

Recent Accomplishments:

Major research cruises conducted by the AFSC included: 1) the annual winter fishery acoustic surveys aboard the NOAA Ship *Miller Freeman* to estimate the biomass and distribution of pollock in Steller sea lion critical habitat around the Shumagin Islands, southeastern Bering Sea (including the Bogoslof Island area), Shelikof Straits and along the eastern side of Kodiak Island; 2) 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; 3) a biennial summer bottom trawl survey of the Gulf of Alaska shelf and continental slope groundfish with three chartered fishing vessels to estimate the biomass and distribution of groundfish and to collect other biological data; 4) a pilot summer fishery acoustic survey aboard the NOAA Ship Miller Freeman to determine the feasibility of conducting a biennial summer Gulf of Alaska survey to estimate the distribution and abundance of pollock off bottom over the shelf; 5) 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, 6) an annual bottom trawl survey for shrimp in Pavlof Bay; 7) spring, summer, and fall surface trawl surveys by the NOAA Ship John N. Cobb to determine abundance, migration patterns, ecology, bioenergetics, and carrying capacity for juvenile salmon in Southeast Alaska waters; and 8) fall surface trawl surveys of the eastern Bering Sea shelf and basin with chartered vessels to determine distribution, relative biomass, habitat, and ecology of western Alaskan salmonids.

The AFSC runs an observer program to collect information from the federally regulated fisheries of Alaska. The observer program collected valuable data on the target fishery resource for the purpose of stock assessment. In addition, the observer program estimated the levels of direct, incidental takes of all protected species in Alaska's federally-regulated fisheries, including seabirds, prohibited species of fish, and marine mammals.

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 AFSC, in cooperation with the Pacific Marine Environmental Laboratory (PMEL), conducted a number of Fisheries Oceanography Coordinated Investigations (FOCI) research cruises with the support of GLOBEC (Global Ocean Ecosystem Dynamics), the Steller sea lion research program, and the North Pacific Research Board. These studies examined the environmental and biological factors affecting the spatial distribution and relative abundance of juvenile pollock in the Gulf of Alaska and the Bering Sea, particularly with respect to their role in the ecosystem and importance as prey for Steller sea lions.

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

The AFSC, in cooperation with the NPAFC, initiated an international survey titled Bering Aleutian Salmon International Survey (BASIS), to understand the mechanisms underlying the effects of environmental variation and density-dependence on salmon-carrying capacity in the Bering Sea for sustainable conservation of salmon stocks

In 2002, AFSC scientists discovered dense aggregations of deepwater corals and sponge in the Aleutian Islands area and have initiated studies of their distribution and biology.

Oiled beach from the *Exxon Valdez* oil spill. Photo: NOS.

The AFSC conducted restoration studies stemming from the Exxon Valdez oil spill in Prince William Sound, particularly those relating to the abundance and biological availability of lingering oil.

The AFSC in collaboration with Alaska Department of Fish and Game conducted a sequence of research cruises in the northeastern Bering Sea using chartered fishing vessels to determine the annual cycle in maturity and the reproductive biology of snow crab. The research was followed by two research cruises aboard two chartered vessels to design and evaluate bycatch reduction devices for the reduction of salmon bycatch in pollock midwater trawl fisheries. These cruises were conducted with the full collaboration of the pollock fishing and trawl gear industries.

The AFSC scientists with expertise in conducting bottom trawl surveys lead the development of national trawl survey standardization protocols. Under the direction of the NOAA Administrator, the objective of this project was to develop and publish a standard set of protocols for all aspects of trawl survey preparation and execution to ensure that data meet the highest quality standards and that consistency is maintained from one survey to the next. The national report was submitted and approved on schedule.

A team of AFSC survey biologists compiled the first edition of the At-Sea Safety Manual to educate our scientists about unsafe situations and practices while working aboard chartered fishing vessels conducting trawl surveys. The team will review and update the document on an annual basis.

AFSC scientists have recently completed a major atlas of ichthyoplankton abundance and distribution patterns in the northeast Pacific Ocean and the Bering Sea ecosystems. The atlas contains detailed information on the early life stages of 103 fish taxa and will be readily available to a wide range of investigators both in print form and on-line.

The NMML conducted research to determine the status, conservation needs, and potential impacts of fishing activities on marine mammals of Alaska. Based on data collected by the Center's observer program, federally regulated fisheries are not

considered to have a direct, incidental take level of marine mammals high enough to warrant management action. However, indirect interactions between some commercial fisheries and some species of marine mammals (e.g., Steller sea lions and northern fur seals) may potentially occur. Research to resolve whether and to what extent these interactions occur has included surveys of marine mammal forage fish and the collection of detailed foraging information. The NMML worked closely with the Alaska Scientific Review Group (ASRG) to determine the status of marine mammal stocks in Alaska. The ASRG includes representatives from Alaskan universities, the Alaska Native community, and the commercial fishing industry.

The AFSC (ABL) completed radio-tagging studies on Yukon River chinook and fall chum salmon that documented spawning location, migration rates, and estimated numbers crossing the border into Canada. Genetic baseline information on salmonids was assembled to identify stocks or country of origin. AFSC scientists are key partners in Coastal Fish Habitat Restoration design, application of new aquatic habitat restoration technologies, and in developing the database needed to test the effectiveness of those restoration designs.

Research Priorities, FY 2004–2009:

I.A. Biological research concerning the abundance and life history 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 the off-bottom component of pollock stock in the Bering Sea every 2 years (2004, 2006, 2008) and the Gulf of Alaska (2005, 2007) from the NOAA Ship *Miller Freeman* and / or the new NOAA Ship *Oscar Dyson*.

- Conduct the biennial eastern Bering Sea slope survey for groundfish (2004, 2006, 2008) with a chartered fishing vessel.

- Conduct the annual winter surveys on spawning pollock stocks in the southeastern Bering Sea, Bogoslof Island area (biennial schedule), Shumagin Islands, Shelokof Straits and along the east side of Kodiak Island using the NOAA Ship Miller Freeman and / or the new NOAA Ship *Oscar Dyson*.

- Conduct the biennial summer bottom trawl survey on groundfish in the Gulf of Alaska with chartered fishing vessels every 2 years (2005, 2007, 2009).

- Conduct the biennial summer bottom trawl survey on groundfish in the Aleutian Islands region with chartered fishing vessels every 2 years (2004, 2006, 2008).

Tagged Atka mackerel. Photo: Ivone Ortiz, AFSC.

- Conduct annual summer longline surveys on sablefish resources in the Gulf of Alaska by a chartered vessel and in the Bering Sea and Aleutian Islands on alternate years.

- Conduct annual FOCI research cruises for larval pollock, plankton productivity and ecosystem status, and juvenile pollock ecology from NOAA Ship *Miller Freeman* and / or the new NOAA Ship *Oscar Dyson* and chartered UNLOS (University-National Oceanographic Laboratory System) vessels.

- Conduct annual fall surface trawl surveys on Pacific salmon ecology in the Bering Sea using chartered fishing vessels (2003–2006).

- Conduct annual summer surface trawl surveys on Pacific salmon ecology in the Gulf of Alaska using a chartered fishing vessel (2003–2005).

- Conduct annual Southeast Coastal Monitoring (SECM) surface trawl cruises with NOAA vessel J. N. Cobb to study the habitat use and early marine ecology of juvenile Pacific salmon.

In addition to the above traditional baseline surveys, the AFSC has a Fishery Interaction Team that develops and implements surveys to study the interactions among the component species of the ecosystem, the environment and fisheries. The research includes:

- An annual tag release and recovery cruise for Atka mackerel in the Aleutian Islands to assess the impact of commercial fishing on the local distribution and abundance of Atka mackerel inside and outside Steller sea lion critical habitat.

- An annual Pacific cod pot survey on the Eastern Bering Sea shelf to assess the impact of commercial fishing on the local distribution and abundance of Pacific cod inside and outside Steller sea lion critical habitat.

- Surveys of seasonal, temporal and spatial variations in energy content of Steller sea lion prey.

AFSC is also planning to conduct research cruises to intercalibrate the scientific acoustic survey systems between the NOAA Ship *Miller Freeman* and the new NOAA Ship *Oscar Dyson*: a) to ensure the standardization of the surveys over time series; b) to estimate the selectivity and catchability of standard bottom trawl survey nets; c) to conduct experiments with trawling procedures in order to confirm or revise AFSC trawl survey standards relative to ensuring that the national

trawl protocols are met; and d) to continue research on essential fish habitat determination and to measure the effects of fishing on it. During all standard surveys, biological specimens of fish and invertebrates will be collected to identify new species, estimate biological rates, study prey-predator relationships, and genetic stock structure.

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% observer 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 trends in Alaskan salmon populations and the environment though:

- Operation of a two-way fish weir to relate climatic changes with long-term variability in fresh water and marine survivals for seven anadromous salmonids.
- Retrospective analyses and monitoring programs focusing on the covariance between climate, ocean conditions and Alaskan salmon populations at various time and spatial scales.
- Process-oriented studies on interannual variations in marine carrying capacity and bioenergetics of juvenile salmon including trophic interactions with predators and competitors, food habits, zooplankton prey densities and composition, and condition assessed as energy density.

The AFSC will assess the status of Alaskan groundfish stocks and document their management requirements in annual Stock Assessment and Fishery Evaluation (SAFE) documents. The SAFE documents will define estimates of stock biological production potential (MSY or proxy thereof), recommend levels of acceptable biological catch (ABC), overfishing levels, bycatch requirements, and other harvest control rules for the setting of fishery regulations. The stocks covered are:

- All Bering Sea-Aleutian Islands groundfish stocks or stock complexes that includes EBS pollock, AI pollock, Bogoslof pollock, Pacific cod, yellowfin sole, rock sole, arrowtooth flounder, flathead sole, Greenland turbot, Alaska plaice, other flatfish, Pacific ocean perch, other rockfish, other red rockfish (including shortraker, rougheye, and northern rockfish), Atka mackerel, and sablefish.
- All GOA groundfish stocks or stock complexes including western central pollock, southeast pollock, Pacific cod, arrowtooth flounder, flathead sole, other

Sampling with a beach seine net in eelgrass in Southeast Alaska. Photo: John Thedinga, AFSC

flatfish (including rex sole, deepwater flatfish, and shallow water flatfish), Pacific ocean perch, northern rockfish, other slope rockfish (including shortraker, rougheye rockfish), pelagic shelf rockfish, Atka mackerel, and sablefish. The Alaska Department of Fish and Game will assesses the demersal shelf rockfish complex.

- King and Tanner and snow (opilio) crab in the eastern Bering Sea.

Due to significant conservation concerns caused by the precipitous decline of Steller sea lions, research directed at resolving the nature and extent of indirect interactions between them and commercial fisheries in Alaska will continue. In addition to the research conducted by the AFSC Fisheries Interaction, activities focusing on the Steller sealion / groundfish fisheries issue will include:

- Investigation of overlap between Steller sea lion foraging areas and commercial fishing grounds.
- Use fish bones to estimate length of prey species consumed by Steller sea lions.
- Updating fisheries analytical models to explicitly include potential causes of the Steller sea lion decline.
- Comparative surveys of forage fish abundance and distribution off Kodiak Island and Southeast Alaska.

I.B. Social and economic factors affecting abundance levels

- Expand sociological and economic research and incorporate results into the fishery management process. The process will include the acquisition of data, and development and analysis of socioeconomic models, that are compatible with, and can integrated with, ecosystem models.
- Conduct research on vessel overcapitalization 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 and analyze stomach contents of groundfish to determine ecological linkages between species.

- Develop and maintain multispecies and ecosystem models that quantify predator-prey interactions between species.

- 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 acoustic surveys to estimate distribution and abundance of pollock 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.

- Develop genetic baseline data for selected species of groundfish to establish stock structure and stock boundaries.

- Determine incidence of coded-wire tagged salmonids in commercial and research catches in the North Pacific Ocean and Bering Sea and report annually to Pacific States Marine Fish Commission and North Pacific Anadromous Fish Commission.

- Evaluate the importance of resident rainbow trout on the genetic and biological integrity of anadromous steelhead populations and the impacts on Evolutionary Significant Unit (ESU) determinations.

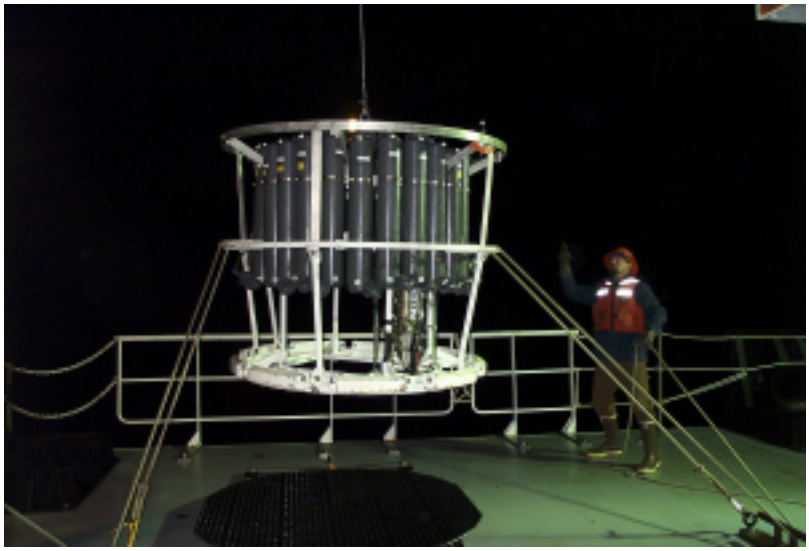
I.D. Identifying, restoring, and mapping of essential fish habitat (EFH)

- 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.

- Conduct acoustic surveys of ocean floor to characterize and identify bottom type and map the habitats of the continental shelf and slope off Alaska.

- Conduct pilot mapping of fishing grounds and essential fish habitat associated with those grounds: describe benthic habitats, community structure of the habitats, and the basic life histories of corals, sponges, and other benthic invertebrates.



CTDROS equipment. Photo: Carol Add, AFSC.

- Conduct studies on the impacts of urbanization, sewage, and vessel traffic on coastal salmon resources in Alaska. NMFS will work with Federal, State, and local governments as well as local organizations to restore urban impacted salmon watersheds.

- Map seasonal and temporal shifts in the use of kelp and eelgrass habitat by nearshore fish assemblages in Southeast Alaska.

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

- Investigate the role of pathogens and parasites in vitality of fish, shellfish, and marine mammal populations and as biomarkers of anthropogenic and environmental change on stock health.

- 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 and investigate the ecological interactions and relationships relevant to the productivity of the ecosystem and ecosystem-based management.

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

- Assess impacts of natural and anthropogenic factors on the production, distribution and abundance of Alaskan groundfish stocks. Products are included in contributions to the ecosystem considerations chapter of the SAFE documents, peer reviewed publications and stock assessment advice.

- Analyze the response of fish populations to changes in climate and the ecosystem.

- Develop, evaluate, and update indicators of climate effects on North Pacific stocks and ecosystems and incorporate these into predictive assessments.

- Evaluate hatchery / wild stock interactions of juvenile chum salmon in inshore and coastal marine habitats of Southeast Alaska to rebuild and maintain sustainable, economically viable fisheries.

- Conduct Ocean Carrying Capacity (OCC) investigations: a cooperative research program with the North Pacific Anadromous Fish Commission and other partners to investigate the factors affecting distribution and survival of Pacific salmon in the Gulf of Alaska and Bering Sea.

- Conduct restoration studies related to the Exxon Valdez oil spill in Prince William Sound. The research will focus on the long-term effects of lingering oil on intertidal organisms. This is part of an interagency study examining transfer of oil from intertidal organisms to bird and otter predators.

- Determine if remote delivery of persistent organic contaminants such as PCBs and pesticides via migratory fish or atmospheric deposition is occurring in Alaskan watersheds.

II. Conservation Engineering Research

Recent Accomplishments:

The AFSC continues to conduct research cruises and to analyze results of recent surveys to measure the direct effects of bottom trawling on seafloor habitat in the 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 pollock midwater fishing vessels to design and evaluate a bycatch reduction device to reduce the bycatch of salmon in their midwater trawls. With the funding support of the North Pacific Research Board, the first observations were made on the capture behavior of salmon in a midwater trawl targeting on pollock. Based on these results, fishermen working with AFSC scientists have developed and evaluated a number of possible designs in a large tow tank in eastern Canada. These designs have been refined and will be evaluated at sea late this summer on a charter vessel. The most promising design will then be used in a commercial operation to evaluate its effectiveness in reducing bycatch of both chinook and chum salmon in the eastern Bering Sea pollock fisheries under actual fishing conditions. If these trials prove effective, then the industry will likely start installing the net modifications for their 2004 fisheries.

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 development of an acoustic pinger resulted in a significant reduction in marine mammal bycatch.

AFSC scientists carried out laboratory experiments on live fish at the Hatfield Marine Science Center in Newport, OR, to determine the impact of stress from capture processes on the behavior and survival of important bycatch species in trawl and longline fisheries. This research provided insights on the key principals which control fish mortality by integrating analysis of behavioral and physiologi-

cal assays and observed mortality. Recent work with sablefish and Pacific halibut have shown that environmental factors, including temperature and air exposure can interact with gear stressors to magnify mortality and susceptibility to stress and mortality. Studies related to the condition of juvenile pollock escaping through codend meshes found that juvenile pollock are a "fragile species," significantly impaired and more vulnerable to predation after escapement from a simulated trawl codend.

Research Priorities, FY 2004–2009:

- Continue to conduct research to measure direct effects of bottom trawling on seafloor habitat according to a 5-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 economic and social research to support fishery conservation and management actions, particularly those of the NPFMC. In terms of that research and data programs to support such research, the principal accomplishments included the following:

- 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.

- In cooperation with NPFMC, ADFG, and PSMFC staff and industry, developed comprehensive economic data reporting requirements as part of the BSAI Crab Rationalization Program recommended by the NPFMC.

- Analyzed economic consequences of fishery management actions including bycatch management, changes to the North Pacific Groundfish Observer Program, and additional protection for Steller sea lions.

- Published research on fishing capacity and other measures of economic productivity, regional economic models, valuing recreational fisheries, subsistence hunting and fishing practices, and subsistence issues in U.S. law.

- Completed a quantitative assessment of excess fishing capacity in federally managed fisheries off Alaska and created multi-input, multi-output parametric primal capacity models that can be estimated with existing, routinely collected data.

- Prepared both the Traditional Ecological Knowledge section of the Draft Programmatic Supplemental Environmental Impact statement (DPSEIS) for the groundfish fisheries and the Tribal Communities chapter of the NMFS Sociocultural Practitioner's Manual.

- Supported the increased use electronic logbooks to provide biological and economic data that are more complete, accurate and timely.

- Hired an anthropologist and completed field work in two Alaska fishing communities in order to develop community profiles and identify indices of the sociocultural impacts of fisheries and fishery management measures.

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 FMPs 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.

Research Priorities, FY 2004–2009:

III.A. Social and economic research

- Assist in implementing and improving data collection programs that support economic and social research.

- Assess the economic and social impacts of current and proposed fishery conservation and management measures and improve assessment methodologies.

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

- Assess the economic and sociocultural performance of the federally managed fisheries off Alaska and improve assessment methodologies.

Euphausiids captured in a survey from the *Miller Freeman*. Photo: Jay Clark and Matt Wilson, AFSC.

III.C. Marine aquaculture

- Conduct stock-enhancement aquaculture research on chinook salmon at the AFSC's Little Port Walter Field Station to determine hatchery strategies that result in an increased contribution of Alaska-origin chinook salmon in Alaska salmon fisheries.

- Conduct parentage analysis of multi-generational hatchery chinook salmon and wild stock cohorts using DNA micro-satellites to determine relative biological and fishery contribution performance measures.

- Measure the effects of 70 years of freshwater sequestration on genetic variability, growth, survival, maturation, juvenile behavior, and adult spawning behavior on normally anadromous steelhead trout with implications for successful restoration of ESA listed stocks.

- Determine effects of different founder regimes on genetic variation in hatchery brood stocks of salmon.

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 Memorandums and Center Processed Reports.

The AFSC has been proactive in web enabling public access to research information. Projects include:

- Development of a web-enabled database of research projects conducted at over 25 institutions throughout the world investigating the cause of the decline of the western population of Steller sea lions.

- Alaska Fisheries Science Center scientists have conducted ichthyoplankton cruises in 1972 and yearly from 1977 until the present. The results are now in a web-enabled database which allows users to search for cruises of interest based on

region, sampling gear, and / or sampling date. The results will return a list of the cruises meeting the search criteria and will link to a synopsis of each cruise.

- Alaska Fisheries Science Center scientists and researchers gather thousands of digital images on the various scientific cruises. The AFSC has web-enabled access to nearly 10,000 images through the deployment of an image management database system.

- Geographic Information Systems (GIS) play a key role in the analysis of data. The AFSC annually conducts training programs for AFSC scientists and researchers on how to use the various GIS tools available to them.

- The AFSC is the host for the National Marine Fisheries Service "Fish News" listserver. FishNews is an automated, e-mail-based newsletter that provides electronic notification of important actions, rules, policies and programs that may be of interest to the public.

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.

AFSC scientists participated as scientific advisors to bilateral technical committees in various international salmon fora including the U.S.-Canada Pacific Salmon and Yukon Treaty accords and the North Pacific Anadromous Fish Commission (NPAFC).

The AFSC database for bottom trawl surveys is undergoing a major restructuring to include all the catch, haul, specimen, and effort data that are being routinely collected. The design is nearly complete and populating the new data base has begun thanks to ESDIM funding support.

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 provided technical expertise and analysis in environmental impact statements involving Alaska groundfish fisheries.

The AFSC is developing ecosystem-based indicators and assessments. This information is being integrated into documents provided to fishery managers in support of ecosystem-based management. Time-series data on climate, fishing, and status and trends of species and ecosystem-level characteristics are being collected from diverse sources and consolidated into a central place to facilitate integrated ecosystem assessments.

The AFSC provided the technical lead role for developing the Marine Fisheries Stock Assessment Improvement Plan for Alaska groundfish. Research activities include a broad spectrum of field research and data analyses that involves other divisions within the Center and partnerships with three Universities.

The AFSC (REFM) continues to provide the technical lead to further define overfishing for uniform applications throughout NMFS. The role also extends into a National Committee tasking to establish new for listing under ESA

Research Priorities, FY 2004–2009:

- Develop processes and procedures which will enhance the communication of scientific information generated by the Alaska Fisheries Science Center with emphasis on web-enabled access to its data.

- 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 or Center) conducts research to support the management, conservation, and sustainable use of the Pacific Northwest region's anadromous and marine fishery resources and their habitats. The Center carries out its research from its Montlake Laboratory headquarters in Seattle, WA, and from five research stations in Manchester, Mukilteo, and Pasco, WA, and in Newport, and Pt. Adams, OR. The Center's more than 300 federal employees and 200 non-federal employees conduct both field and laboratory research in coastal, ocean, and estuarine environments, as well as in inland freshwater habitat that anadromous species, like salmon, use.

The NWFSC has several small vessels for conducting studies. The R/V *Harold Streeter* serves Puget Sound while the R/V *Murrelet*, R/V *Siliqua*, and the R/V *Quinnat* serve Columbia River Basin projects. The Center currently does not have a dedicated research vessel, but one is currently being planned. Center scientists currently rely on the NOAA R/V *Miller Freeman* and the *McArthur II*, as well as on privately chartered vessels and academic research ships to supplement the Center's research capability and to conduct critical surveys.

The Center's research brings together a number of disciplines, including fisheries science, marine biology and ecology, genetics, biochemistry, molecular biology, oceanography, and physiology. Organizationally, the Center consists of the Conservation Biology Division, the Environmental Conservation Division, the Fish Ecology Division, the Fishery Resource Analysis and Monitoring Division, and the Resource Enhancement and Utilization Technologies Division. In addition, the Center has Socioeconomics, Marine Mammal, and Science Synthesis and Coordination programs. Across these five divisions and programs, NWFSC scientists and staff conduct research in five primary areas:

- Status of stocks—Center scientists conduct and coordinate stock assessments for west coast groundfish and salmon stocks in the Pacific Northwest by taking a variety of measurements, analyzing the data, and using mathematical models to draw conclusions from the results. These assessments are one tool used by managers to set biologically sustainable harvest levels for healthy stocks and to identify and guide the monitoring and rebuilding of overfished and threatened stocks.

- Human Caused Stress/Risks—Center scientists conduct research to better understand how salmon, marine fish, and marine mammals react to these stresses and to quantify, assess, and minimize these risks. The Center's research provides the underpinning for management decisions.

- Ecosystem and Climate Characteristics—Center scientists conduct research on physical and biological processes that influence aquatic, marine, and estuarine

The NWFSC Montlake Laboratory in Seattle, WA.

ecosystems in the Pacific Northwest, as well as the effects of invasive species, toxic phytoplankton, climate change, and natural environmental fluctuations.

- Recover and Rebuild Species—Center scientists study genetic variation and conduct research on the population structure of salmon, marine fish, and killer whales. The Center also develops innovative recovery tools like captive broodstock programs to propagate salmon species, new techniques for rearing hatchery fish, and culture techniques to rear marine fish. In addition, Center scientists are directly involved in salmon recovery planning efforts on the west coast.

- Innovation and Technology—Center scientists are taking a lead role in developing and applying technologies, techniques, and tools to support conservation and recovery of the Pacific Northwest's living marine resources. Over the years, the Center's innovative and original research has helped establish new aquaculture endeavors, seafood processing techniques, dam passage equipment and techniques, methods to detect and evaluate harmful algal blooms, and technology to integrate and track important fisheries dependent data, as well as to identify and monitor marine and anadromous fish populations.

The Center has lead responsibility in the region to study and provide state-of-the-art scientific information on the following primary living marine resources.

- Pacific Salmon—Fifty-two populations or evolutionarily significant units (ESUs) of salmon and steelhead exist on the west coast, 26 of which are listed as endangered or threatened under the Endangered Species Act.
- West Coast Groundfish—The west coast groundfish fishery includes some 80 commercially fished stocks and supports millions of dollars in economic activity and many livelihoods. The Center coordinates NMFS' Groundfish Program on the west coast.
- Killer Whales—The Southern Resident killer whale population was recently listed as depleted under the Marine Mammal Protection Act. The Center has developed a research plan to address possible causes for the killer whale decline and gain a better understanding of the physiology, ecology, and behavior of these whales.

As part of the Center's studies of these living marine resources, Center scientists also conduct research that helps predict how marine resources respond to environmental variability and climate change, the nature and location of habitat resources required by commercially valuable fish species, and habitat interactions between fish and marine mammals.

The NWFSC develops and maintains strong collaborative partnerships with state and Federal agencies, industry, environmental groups, Native American tribes, individual fishers, universities, and other research and academic institutions. The Center also provides opportunities for students in marine research, technology, and library science through cooperative research agreements with regional universities and councils.

NWFSC research supports critical management decisions. Center scientists continually strive to improve the state-of-the-art of the scientific information they provide.

RECENT ACCOMPLISHMENTS AND RESEARCH PRIORITIES FOR FY2004–2009

I. Research to Support Fishery Conservation and Management

Recent Accomplishments

Developed comprehensive research plans for west coast groundfish, hatchery science, socioeconomics, watershed ecology, and Pacific salmon to ensure that all relevant scientific information is available to regional managers and policy makers. All plans were reviewed by external scientists and constituents.

Convened a series of program reviews using external panels of scientists to evaluate the quality and appropriateness of the Center's science in four major areas: artificial propagation, ocean and estuarine ecology, watershed ecology and recovery planning, and groundfish.

Conducted extensive assessments of west coast groundfish species and analyzed the potential for rebuilding species classified as overfished. Center scientists completed stock assessments for Pacific whiting and canary and yelloweye rockfish, updated the stock assessment for sablefish, and coordinated rebuilding analyses for widow and darkblotched rockfish.

Expanded its annual series of slope species surveys from Cape Flattery, WA, to the Mexican border (previously surveys ended at Morro Bay, CA). The Center also expanded these surveys to include both shelf and slope trawl collections. This combined survey is designed to provide comprehensive information on the status of ecologically and economically important groundfish populations. A newly-adopted stratified random sampling scheme was implemented this year to improve the survey design and help provide baseline observations on seabed types for future development of groundfish habitat maps. These surveys provide information about distribution, relative abundance, and age structure of important groundfish populations.

A researcher working with *Vibrio vulnificus*, an organism that colonizes molluscan shellfish. Photo: NWFSC.

Developed and implemented a new Pacific whiting acoustic survey, which was conducted jointly with Canada to improve timeliness of stock assessments for this species. In 2003, the survey was restructured to be fully cooperative and included a contingent of both U.S. and Canadian scientists along each leg of the cruise. This new biennial sampling regime will provide better tracking of the Pacific whiting population.

Initiated a hook-and-line survey, in cooperation with sportfishing and commercial industry vessels, for bocaccio and other shelf rockfish in the Southern California Bight. This survey will improve the information base for groundfish species that are often not adequately sampled during the annual trawl survey and will augment knowledge and expertise of fisheries in this historically under-sampled region.

Continued to coordinate the west coast Observer Program. In 2002, the Center added approximately 20 observers to its Observer Program in California, Washington, and Oregon ports, bringing the total number of observers to about 40 coastwide. The Observer Program released, in 2003, the summary and analysis of the first year's observations of the trawl fleet. The data are the most up-to-date and accurate groundfish catch information on the west coast. The Center also organized and hosted a workshop to explore options to enable the agency to more effectively deploy observers on small boats.

Chaired a Biological Review Team to review the status of the Southern Resident killer whale population. The team evaluated whether these whales were a distinct population of the global killer whale species, why the whale population has been declining, and estimated the risk of extinction of this stock.

Co-hosted with the Washington Department of Fish and Wildlife two killer whale-related workshops, one on vessel interaction and the other on prey, with participation from local, regional, national, and international experts to identify the most important research questions to improve our understanding of the low survival and reproductive success of Southern Resident killer whales.

Created a Southern Resident killer whale research plan. The Center is implementing research projects with local, regional, national, and international experts to address possible causes for Southern Resident killer whale decline and to gain a better understanding of their physiology, ecology, and behavior.

Updated, in cooperation with Southwest Fisheries Science Center scientists, the status reviews of all currently listed salmon and steelhead evolutionarily significant

units (ESUs), as well as one candidate species population, to consider new data that had accumulated since the mid-1990s and to address issues raised in recent court cases regarding the consideration of hatchery and resident fish populations in listing determinations.

Continued to chair three salmon Technical Recovery Teams (TRTs): Puget Sound, Lower Columbia River and Willamette River, and Interior Columbia River Basin, and co-chaired the Oregon and Northern California Coast TRT. TRTs are describing the biological conditions that are necessary for recovery of listed populations and are providing technical support to policy makers to help evaluate alternative strategies for meeting recovery goals. The Center developed the original TRT concept, purpose, and goals.

Developed a Cumulative Risk Initiative (CRI) to assess salmonid population trends and the impact of various actions across the entire salmonid life cycle. This framework has enabled scientists to evaluate how actions in different portions of the salmon life cycle may improve survival, reduce risks, and foster recovery.

Conducted critical surveys to assess juvenile salmon abundance, distribution, growth, and health in estuarine environments and to determine how changes in ocean conditions affect juvenile salmon.

Conducted studies to investigate prespawn mortality in adult coho salmon from urban streams and co-hosted, with Seattle Public Utility District, a public meeting to discuss preliminary results and develop a more comprehensive and collaborative research effort.

Spearheaded a multimillion dollar research project to study the ecology and oceanography of *Pseudo-nitzschia*, the algae that produce the neurotoxin domoic acid. The first two of six cruises were conducted in summer 2003 to measure the physical, chemical, and physiological conditions under which the algae produce and release the toxin domoic acid into the environment.

Continued critical studies to evaluate the potential delayed effects of juvenile salmon passage through the Columbia River Hydropower System. Center scientists found that the salmon smolts' passage history through the Columbia River was related to differences in their survival and immune system function.

Conducted a large study using radiotelemetry and PIT-tag technology to evaluate total project survival, route-specific survival, and fish passage behavior at Ice Harbor Dam for yearling and subyearling chinook salmon.

Established a new initiative on the science for ecosystem-based management to provide scientific advice on the ecological processes necessary to sustain ecosystem composition, structure, and function in the environments in which fish and fisheries exist.

Co-led an expedition to study and compare Astoria Canyon, a submarine canyon

off the mouth of the Columbia River, with Heceta Bank, a historical groundfishing location and submarine plateau off Oregon's coast. Scientists mapped, explored, and documented the physical, chemical, and biological systems of the Canyon.

Continued research designed to estimate the relative reproductive success of naturally spawning hatchery salmon.

Developed a method to differentiate strains of *Vibrio vulnificus* with high potential to cause infection in humans from those that are less virulent.

Continued to work on combining biological and economic data in assessing the cost-effectiveness of screening irrigation diversions in the Salmon River basin.

Developed a framework for analyzing the economic impacts of critical habitat designation for salmon and steelhead under the ESA, and contracted with an outside party to conduct a prospective study of these impacts. Work was also done on identifying potential economic benefits of the critical habitat designations.

Initiated a study of conservation banking, a means of reducing the costs of mitigation when economic development adversely affects the habitat of an endangered species.

Created a stronger link for cooperative research through a Memorandum of Understanding with Washington State University to advance salmon recovery efforts in the interior Columbia River Basin.

Research Priorities, FY2004–2009

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

- Conduct baseline assessments for managed groundfish species.
- Improve the level of certainty and confidence in assessments, particularly for stocks with rebuilding plans and intensively fished and managed species.
- Increase groundfish surveys in untrawlable and nearshore habitats using ROV, submersible, fixed gear, and acoustic surveys.
- Expand the geographic and seasonal extent of existing pre-recruit surveys to provide more precise information on more species.
- Continue the biennial sampling regime for Pacific whiting. Regular assessments are key for estimating stock size and act as the foundation for advising international harvest levels.
- Participate in the California Current ocean observing program through the Alliance for California Current Ecosystem Observations.

- Develop biologically based delisting goals for listed salmon and steelhead. This work will be carried out by the Puget Sound, Willamette / Lower Columbia River, Columbia River Basin, and Oregon and Northern California Coast Technical Recovery Teams.

- 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.

- Continue to conduct west coast groundfish resource surveys from the U.S.-Canada to U.S. Mexican border to improve stock assessments.

- Deploy observers in the groundfish trawl fishery to improve information on total catch for management decisions, and expand observer coverage in other groundfish fisheries. Observers are providing critical new information on by-catch and nontarget and protected species for management of the 82 species under the west coast groundfish Fishery Management Plan.

- Conduct studies on the winter distribution, habitat, and prey of Southern resident and transient killer whales.

- Conduct research on prey resources and contaminants in killer whale prey.

- Conduct Genetic Stock Identification studies to help determine stock allocation under the Pacific Salmon Treaty, help elucidate the ocean migration patterns of listed salmon stocks, and compare different methods of stock identification.

I.B. Social and economic factors affecting abundance levels

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

- Develop methods and collect data to facilitate the integration of social science into recovery planning for endangered species.

- Investigate the value of incorporating local knowledge into the design and management of marine protected areas.

I.C. Interdependence of fisheries or stocks of fish

- Explore and quantify the ecological linkages of salmon distribution and survival in estuarine and near shore environments

- Assess both the positive and negative effects of hatcheries on wild salmon populations by measuring the relative fitness of hatchery fish and their descendants

Researchers aboard the R/V *Harold Streeter* collecting fish in Puget Sound for analysis. Photo: NWFSC.

when they spawn in the wild and by developing and applying methods for addressing the ecological risks associated with hatcheries.

- Develop and apply population viability models that take into account the genetic and ecological effects of hatchery production.
- Conduct research to better understand and quantify the importance of genetic diversity within and among fish populations.
- Develop and apply molecular genetic tools to identify species, stocks, and individuals.
- Use molecular tools to study the predator / prey interactions between marine mammals and fish populations.
- Use bioenergetic models to provide information on how rockfish growth and consumption are related to climate variability and how changes in mortality propagate through rockfish to their major prey species.
- Characterize and quantify ecosystem services associated with salmon and steelhead populations and their habitats.

- Develop, with partner institutions, a Pacific Coast Observation System.
- Improve understanding of the effects of decadal-scale ocean climate fluctuations on fish productivity to improve forecasts of available yield, improve forecasts of the time needed to rebuild overfished stocks, and improve our ability to understand past trends.
- Develop better indices of ocean conditions to evaluate salmon survival in marine environments.

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.
- Assess the economic cost and other social impacts of habitat restoration and protection as a strategy for recovering endangered species.

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

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

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

- Conduct hydroacoustic surveys to study the distribution and abundance of groundfish species.

- Map and verify essential fish habitat for west coast groundfish.

- Expand surveys to determine how natural fluctuations in the marine ecosystem affect fishery productivity, how human-caused stress affects the ecosystem and fishery, and the complex interactions between fish and their habitats.

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

- Develop a biophysical model that will enable forecasting of HAB events on the U.S. west coast.

- Continue studies to improve our understanding of the fitness of hatchery fish.

- 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.

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

- Establish threshold values for contaminant effects so biological effects on species can be predicted.

- Investigate the impact of ocean variations on salmon by studying salmon distribution, abundance, food habitats, and predator-prey relationships.

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

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

- 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.

A fish ladder opening with PIT-tag antennas, part of a new detection system for adult salmon. Photo: NWFSC.

- Quantify how salmon use stream and river habitats by collecting descriptive information and 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.
- Improve understanding of the ecological effects of fishing, including which habitats and populations are most susceptible to such impacts, and ways to reduce adverse impacts.
- Provide technical guidance to Technical Recovery Teams on the effect of 12 known classes of toxic contaminants to salmon recovery.
- Conduct studies on the effects of vessel interactions on Southern Resident killer whales and on the effects of climate change on prey of these whales.
- Conduct research on fish prey resources and contaminants in the prey of killer whales.
- As the lead contaminant analysis entity, continue to analyze samples for contaminants under the Marine Mammal Health and Stranding Network.
- Investigate the role of pathogens and parasites in vitality of fish and shellfish populations and as biomarkers of anthropogenic and environmental change on stock health.
- Investigate the response of fish populations to changes in climate and ecosystems.

II. Conservation Engineering Research

Recent Accomplishments:

Developed, implemented, and refined a model for projecting bycatch of west coast groundfish species that have been declared overfished. The model produces total bycatch tonnage estimates that are crucial for evaluating whether proposed management of target species is consistent with efforts to rebuild overfished stocks. Beginning in 2003, bycatch and discard rates used in the model were derived from data gathered by the NWFSC's West Coast Observer Program.

Continued cooperative activities, using Center-developed captive broodstock technology, to spawn sockeye salmon captive broodstock for use in stock restoration activities. This effort returned more than 300 sea run adults to the Stanley Basin Lakes over the last four years (1999–2002). This is a 19-fold increase over the number of fish returning to the Lakes during the prior eight years (1991–1998).

Provided critical information regarding salmon migration behavior, passage, and survival, using PIT-tag technology. The PIT-tag is a small device, about the size of a grain of rice, with a computer-chip that has been used for many years to detect juvenile salmon as they move downstream. Prototype systems to detect adults returning to spawn have now been installed and evaluated at several Columbia River dams.

Continued to develop and use acoustic (sonar-based) technologies that use high-frequency sound pulses to measure groundfish abundance and map their distribution. These technologies are enabling scientists to study groundfish in many more areas of the ocean.

Began testing, at production scale, in cooperation with the Washington Department of Fish and Wildlife, natural rearing enhancement raceways (NATURES)—hatchery raceways enriched with cover, structure, and substrate to provide salmon with a more "wild-like" environment. These tests will help determine NATURE's effects on salmon survival once the salmon are released from hatcheries.

Began research on early life history of west coast groundfish species.

Developed breeding and rearing technologies for several key groundfish species. Center scientists developed new culture techniques to successfully rear yelloweye rockfish through its sensitive larval phase. This is the first time that this species has been reared in captivity beyond 30 days. Yelloweye rockfish stocks are severely depleted with rebuilding plans that are estimated to take from 40-170 years using current management approaches. The successful culture of yelloweye rockfish larvae is the first step needed to determine if stock enhancement strategies can assist in the rebuilding process.

Worked with partners to develop a new trawl design that is more effective at catching flatfish.

Research Priorities, FY 2004–2009:

- 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.

- Develop conservation hatchery technology to aid recovery of ESA-listed stocks of Pacific salmon.

- Further develop the Natural Rearing Enhancement System (NATURES), a system that cultures Pacific salmon in raceways that simulate natural environments

Researcher entering data in a new on-board data collection system. Photo: NWFSC.

to develop salmon with characteristics and behavior more like their wild counterparts.

- Develop and improve broodstock technology to restore depleted Pacific salmon stocks.

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

- 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.

- Develop new technology to study prey resources and distribution of killer whales.

- Develop and employ advanced and innovative technologies to monitor and survey fisheries and marine ecosystems.

III. Research on the Fisheries

Recent Accomplishments:

Provided evidence, in cooperation with University of Washington scientists, showing that an important source of *Pseudo-nitzschia*, the algae that produce the neurotoxin domoic acid, may be located off of Cape Flattery in the Juan de Fuca eddy.

Initiated a program to collect west coast recreational fishing data with an emphasis on participation in the recreational groundfish fishery.

Conducted a comprehensive review of existing west coast groundfish trawl cost-earnings data.

Developed objectives and methodology for cost-earnings data collection program covering west coast groundfish fisheries.

Conducted a pilot research project on methods for enumerating and profiling Washington Coast groundfish communities.

Initiated community profile database research for west coast fishing communities.

Hired an economist and anthropologist to develop models and collect data on recreational fisheries and improve critical socioeconomic studies.

Successfully captured, spawned, and reared, for the first time, Puget Sound Pacific cod larvae, which will help determine if the stocks that traditionally spawned in Puget Sound differ genetically from the larger Pacific cod stocks and if cultured juveniles can be used to rebuild Pacific cod in Puget sound.

Increased communication between resource managers and research scientists to create an effective HAB monitoring program, which includes early warning of shellfish toxification events. This approach has led to a greater number of beach openings for razor clam harvest. Legislators in Washington recently permitted an increase in razor clam digging license fees to enable the program to continue under state support.

Research Priorities, FY 2004–2009:

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.

- Develop an economic data collection program and models of economic performance for west coast groundfish fisheries

- Collect and analyze stated preference and expenditure data for west coast recreational fisheries

- Develop economic models of bycatch for west coast groundfish fisheries

- Investigate the interdependence of west coast fishing communities on one another and their social and economic dependence on North Pacific and other non-west coast fisheries

- Describe and enumerate west coast environmental justice fishing communities

- Characterize and quantify non-consumptive economic and social values associated with Northwest marine mammal populations

- Analyze the economic and social impacts of fishery closures brought on by harmful algal blooms and other marine biotoxins

- Conduct research and data collection to prepare the economic status of west coast groundfish fisheries as part of the annual Groundfish SAFE reports.

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.

- Identify and characterize key virulence determinants that enable *V. vulnificus* to cause human infections, using comparative genomics and other molecular genetic means. This information will be used to develop methods to treat the disease caused by this pathogen.

- Develop rapid methods to identify and characterize pathogenic bacteria in seafood-related products. These include rapid and easily-used "kit" methods to detect pathogenic strains of *V. vulnificus* from nonpathogenic ones.

- Expand identification of parasitic infections in commercially important marine fish, both geographically and in the number of different marine fish species examined, to better determine environmental variables that alter infection.

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:

Developed a web-based salmon database that is currently available on-line. This database consolidates existing data from hundreds of sources into a consistent database that is geospatially linked.

Developed, with the Office of Marine and Aviation Operations, a portable version of the Fisheries Scientific Computer System (FSCS) for use on charter vessels used for west coast surveys. The FSCS is a data acquisition system designed specifically to digitally collect all critical fishery-independent data aboard fisheries research vessels.

Developed a prototype of the Electronic Fish Catch Logbook—a system for collecting and integrating fishery-dependent data from fishers, processors, observers and biologists using electronic means.

Launched a new website, which provides critical information to the public on the Center's activities.

Expanded participation in a collaborative partnership that is being led by Oregon Sea Grant to create a website that strengthens the connection of fishermen, fishing families, industry, communities, agencies, and other groups. The website posts current information on industry, safety, family, and seafood issues.

Partnered with the Pacific States Marine Fisheries Commission, Pacific Fishery Management Council, and the Pacific Marine Conservation Council to create a new cooperative research website. This website will serve as a west coast-wide clearing house for information on cooperative fisheries research and is intended to match parties with interests in collaborative research and identify a broad range of funding sources.

Research Priorities, FY 2004–2009:

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

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

- Continue expanding capabilities and consolidating existing data from hundreds of sources into a consistent database that is geospatially linked to support salmon and groundfish analyses.

- 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.

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. The current staffing level involved in MSFCMA-related activities is at about 95 full-time equivalents (FTEs). An estimated 55% of total SWFSC resources are assigned to MSFCMA activities. NOAA research vessels assigned to fisheries research in the SWFSC are the NOAA R/V *David Starr Jordan*, which has San Diego, CA, as its homeport, and about two-thirds of the NOAA vessel *McArthur II*'s time. The Center also charters in excess of 100 sea days annually aboard both fishing and research vessels.

The SWFSC is a world-class research organization which conducts integrated, multidisciplinary 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 and high-seas fishery resources. These activities support the scientific, statistical, and economic needs of the Pacific Fishery Management Council 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).
- Groundfishes of the west coast (Pacific hake, rockfishes, lingcod, cowcod).
- Small coastal pelagic species of the west coast (northern anchovy, sardine, mackerel, squid).
- Salmon of the west coast.
- Antarctic krill, crabs, 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, Pacific billfish, tunas and sharks (in collaboration with the Pacific Islands Science Center), 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

The Southwest Fisheries Science Center La Jolla laboratory.

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-founder and co-participant in the Pacific Coastal Observing System (PaCOS) an extension of the now famous State-Federal California Cooperative Fisheries Investigations (CalCOFI), a comprehensive long-term study of the biology and oceanography of the California Current. In the Pacific, the Center is the leading source of stock assessment expertise on tunas, sharks, and billfishes for international commissions and for the Pacific Fishery Management Council. 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 a NOAA CoastWatch node at its Pacific Fisheries Environmental Laboratory.

SWFSC scientists have taken the lead in characterization of large- and small-scale habitats that support white abalone, groundfish, and bottomfish populations in deep water off California. This work requires an interdisciplinary approach from fishery biologists, geologists, and ecologists and couples the use of GIS with remote-sensing visual and acoustic tools, in-situ survey techniques using remotely operated vehicles, submersibles, and spatial analyses. This approach is being applied to the identification of EFH for various species, the improvement of stock assessment surveys, development of endangered species recovery plans 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 and growing 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.

RECENT ACCOMPLISHMENTS AND RESEARCH PRIORITIES FOR FY 2004–2009

I. Research to Support Fishery Conservation and Management

Recent Accomplishments:

Studies on the basic biology, movement, and population status of North Pacific Highly Migratory Species and sharks (HMS) were completed and incorporated into the PFMC HMS Fishery Management Plan, the most recent FMP for the management of HMS resources in the North Pacific. This work has involved col-

laboration with fisheries scientists from around the Pacific, including scientists from the Pacific Islands Science Center, state, university, and resource user groups.

A multinational synoptic survey of krill biomass of Antarctic Statistical Subarea 48 (Peninsula, S. Orkney, S. Georgia, and S. Sandwich) was completed. As a result of a 5-year planning effort, one ship from the U.S., United Kingdom, Japan, and Russia each conducted a 1-month acoustic / oceanographic survey of the above areas and the open-ocean areas between each island group. This was a CCAMLR-sponsored survey with the participation of scientists from the International Whaling Commission. The U.S. convened a CCAMLR workshop to complete analyses of survey data.

The Groundfish Program provided PFMC with stock assessments for bocaccio rockfish, cowcod rockfish, widow rockfish, canary rockfish (south), and lingcod (south), as well as rebuilding analyses for bocaccio and cowcod rockfish and Pacific ocean perch. SWFSC staff initiated and convened a review of harvest rates for west coast groundfish, resulting in significant revision of PFMC management policy. Midwater trawl surveys provided annual indexes of rockfish recruitment strength for use in stock assessments and analyses of environmental influences.

A recent analysis of atmospheric observations in the North Pacific revealed extensive decadal-scale variations in the mid-latitude winter surface wind stress. In the decade after the winter of 1976, eastward wind stress doubled over a broad area in the central North Pacific and the core of the North Pacific Current was displaced about 360 nautical miles southward. The result was that surface water entering the California Current was of more subtropical origin in the post-1976 decade. All factors considered contributed to a multi-decadal temperature pattern of warm, nutrient-poor surface waters in the California and Alaska current regions. In association with the 1976 climatic shift, marine fishery production in the Oyashio, California, and Alaska currents altered dramatically, suggesting that natural environmental variation significantly alters the long-term yields from many North Pacific fisheries.

Research Priorities, FY 2004–2009:

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

- Conduct biological research by the U.S. Antarctic Marine Living Resource Program concerning abundance and life history parameters of fish stocks.

- Plan, conduct, and present results of annual predator / prey interaction studies in waters around South Shetland Islands, Antarctica.

- Develop a new Bayesian method of stock assessment for application to data-poor groundfish species.

- Develop an advanced technology-based groundfish survey using optical technologies and sonar for the Southern California Bight.

- Develop a population genetics database of all anadromous California salmonid stocks for determination of stock structure and as a baseline for future monitoring efforts.

- Provide quantitative estimates of the take of listed salmon in the California salmon harvest and evaluate proposals to minimize listed species take.

- Expand the archival tagging program for North Pacific albacore in cooperation with the albacore fishing industry, Japanese fishery agencies, and other groups to trace albacore movements between fisheries and countries.

- Define unit stocks using genetics and otolith chemistry in highly migratory species (albacore, thresher shark, and striped marlin), in coastal pelagic species (sardine), and in groundfishes.

- Conduct peer-reviewed assessments and statistical analyses on stocks of groundfish, coastal pelagics, tunas, sharks, swordfish, salmon, and other species.

- Develop a new generation of stock assessment models for highly migratory species and coastal pelagic species stocks of the Pacific and the state-of-the-art software to support them, using modern statistical optimization techniques, Bayesian methods, and object-oriented programming languages.

- Use pop-up satellite tags to identify forage and migration habitats of exploited shark species in the California Current.

I.B. Social and economic factors affecting abundance levels

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

- Develop behavioral models of economic incentives affecting the level and allocation of fishing effort in FMP fisheries.

- Initiate an economic survey of the Southern California HMS recreational fishery.

- Enhance existing salmon harvest models to better predict fishing effort response to changes in sport and commercial fishery regulations.

- Conduct Regulatory Impact Reviews and Regulatory Flexibility Analyses for management actions being considered for all FMP fisheries.

- Evaluate growth in productivity for purse seine vessels harvesting tuna in the western and central Pacific, paying special attention to the effects of fish aggregating devices (FADs).

Market squid, *Loligo opalescens.*

I.C. Interdependence of fisheries or stocks of fish

- Continue research program under the International Dolphin Conservation Protection Act to determine whether the chase-and-encirclement practice by the fishery is having a significant adverse impact on depleted dolphin populations in the eastern tropical Pacific.

- Design sampling surveys to analyze the impact of marine mammals on listed salmon.

- Develop integrative oceanic environmental indices to improve understanding of how environmental variability affects fish stocks.

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

- Participate in salmon EFH identification and protection.

- Develop and produce digital mosaics of seafloor habitats from electro-optic images into a format compatible with other geo-referenced data sets used in GIS.

- Develop approaches to evaluate essential habitat of pelagic fishes based on satellite remote sensing and applications of archival and pop-up satellite tags.

- Evaluate EFH and monitor marine resources in newly created "no-take" marine reserves planned for the Channel Islands National Marine Sanctuary.

- Define essential spawning habitat of market squid and the effects of fishing gear on that habitat and the survivorship of demersal egg capsules.

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

- Investigate relationship of juvenile salmon abundance and physiological status with respect to oceanographic features (e.g., estuary plumes, upwelling centers, coastal jets, eddies, and fronts).

- Determine the effects of hatchery and aquaculture operations on indigenous salmon and steelhead stocks in California by molecular genetic analysis of museum specimens and previously collected scale samples.

- Evaluate the effects of climate change of interannual, decadal, and centennial scales on fisheries and fish habitat.

- Develop models of the impacts on salmon populations of natural disturbances due to climatologies.

- Improve methods to identify pathways in estuarine ecosystems for the bio-accumulation of contaminants in salmon.

- Examine the association of recruitment of young rockfishes and climatic and oceanographic variables off central California.

- Investigate use of small estuaries on the central California coast by juvenile salmonids. Assess the effects of environmental variability, particularly sandbar dynamics and water quality, on growth, development, and survival.

- Investigate the linkage between the dynamics of oceanic features, including eddies, fronts, and boundary currents, and the dynamics of highly migratory fishes (tunas and billfishes) in the central and western Pacific.

II. Conservation Engineering Research

Recent Accomplishments:

An analysis of acoustic backscatter from an acoustic Doppler current profiler (ADCP) and surface temperature and salinity continuously sampled in relation to the continuous underway fish egg sampler provided a description of the sardine spawning habitat. This detailed observational analysis shows, on a survey-by-survey basis, that eggs and larvae are found in waters that are transitional between those that are freshly upwelled and those of the California Current proper.

The SWFSC completed research to improve our understanding of fisheries impacts on marine ecosystems. The study pioneered the use of the combination of acoustic techniques, fishing information, and direct submersible research to directly evaluate deepwater fisheries habitat. Research published considered the potential of side-scan sonar to enumerate the frequency of trawl tracks on soft bottom environments, suggesting that acoustic remote sensing is a promising independent approach to evaluate fishing effort on a scale consistent with commercial fishing activities.

Research Priorities, FY 2004–2009:

- Undertake studies to determine the most effective methods to increase survival of sea turtles on nesting beaches in the eastern and western Pacific.

- Determine how to increase survival in the economic / regulatory discards of undersized tunas, sharks, and other fishes.

- Create and test new trap designs for juvenile out-migrant salmon that will minimize predation on juveniles from larger salmonids (in cooperation with Humboldt State University).

- Develop advanced survey technology for monitoring abundance of fishes including: 1) use of LIDAR for monitoring the abundance of CPS species; 2) remote monitoring of FAD fish aggregations; and 3) species identification algorithms for acoustic surveys.

- Develop advanced technology for automatic shipboard data logging of bioacoustic and environmental data from standard equipment on commercial fishing vessels and logging of catch. Develop algorithms for processing and analysis of these data.

III. Research on the Fisheries

Recent Accomplishments:

The SWFSC initiated and led the efforts to evaluate MPAs as a supplemental tool for groundfish management on the west coast. The Center organized and convened the first workshop on marine harvest refugia to conserve and manage rockfish and continued these discussions in a special symposium on marine protected areas for California. The published proceedings and reports are also being used by west coast states in evaluating marine reserves as a strategy to conserve and manage nearshore marine resources.

Coho salmon production in the Pacific Northwest reached historically low levels in the 1990s, which stimulated research examining whether changes in ocean conditions were responsible for interannual variability in the ocean survival of coho. Recent investigations focused on improving the measures of ocean conditions using remotely sensed sea surface temperature (SST) data and by weighting upwelling indices with sea surface temperatures. The models generated from the analyses may have the potential to be used for coho survival forecasting. Related research evaluated how spatial patterns of environmental variability may differentially affect parts of the coho populations.

The SWFSC completed an analysis of harvesting capacity in the Pacific coast CPS limited entry finfish fishery. The Center also collaborated on an analysis of harvesting capacity in the Pacific coast market squid fishery. The Center completed cost-earnings surveys on drift gillnet and albacore troll fisheries as a part of the new HMS FMP. Multifan CL was applied to develop stock assessments for highly migratory species.

Research Priorities, FY 2004–2009:

III.A. Economic research

- Initiate economic evaluation of salmon hatchery reform actions.

- Develop automated analytical templates integrated with current fishery performance, cost, and price information for completing RFAs in an efficient and

timely basis. Augment these templates to include the basic demographic information required to initiate preliminary SIAs.

- Conduct research to support the United Nations Implementing Agreement (or Provision of the United Nations Convention on the Law of the Sea (UNCLOS) Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks).

- Research intra-industry linkages and develop input-output relationships to describe and model the employment, income, and economic activity impacts of management actions being considered for each of the FMP fisheries and fishing communities.

- Evaluate and describe economics associated with sea turtle conservation and develop models for increasing national benefits.

III.C. Marine aquaculture

- Develop techniques for culture of white abalone and other abalone species for recovery of endangered stocks, stock enhancement, and commercial production.

IV. Information Management Research

Recent Accomplishments:

The SWFSC's Pacific Fisheries Environmental Laboratory (PFEL) provides environmental data for fisheries research and management. Environmental variability has been identified as a key feature in fish and marine mammal population dynamics. PFEL's data holdings and related data products provide fisheries relevant data that cover the entire spectrum of the ocean environment-from surface or near-surface wind and pressure data that can affect the ocean, to surface and subsurface measurements of important oceanographic parameters. Over the last year, PFEL has developed a system to make this information readily accessible to fisheries scientists. Scientists can now obtain over the Internet most of the PFEL's data holdings, for any location in the world. The data can be sorted in both space and time, visualized on-line, and downloaded in a variety of formats. Data and expertise were provided to researchers working on salmon survivorship, hake catches and negotiations with Canada, harmful algal blooms, rebuilding overfished fish stocks, benthic fauna patterns in sanctuary areas, and marine mammal population dynamics.

Data collected and processed from U.S. purse seiners fishing in the central-western Pacific were computerized, edited, and submitted to the Forum Fisheries Agency (Treaty Manager) as required under the SPTT. This information was reported at the Annual Treaty meeting of the Forum Fisheries Agency in Nuie and also presented at the meeting of the Standing Committee of Tunas and Billfish in

New Caledonia for use in stock assessments of central-western Pacific skipjack, yellowfin, and bigeye tuna stocks.

The SWFSC fielded three observers aboard U.S. troll vessels to collect length measurements of albacore and bycatch estimates to verify and supplement data taken by port samples and in logbook records. The data were computerized and presented to the North Pacific Albacore Workshop in Taiwan and used to assess the status of Pacific albacore stocks. These data were also analyzed and distributed to U.S. albacore fishers.

The SWFSC organized and initiated an ongoing HMS data organization and data sharing committee to address data compatibility, reporting, and availability for data holdings of the Pacific Islands and Southwest Regions and the Pacific Islands and Southwest Science Centers.

Research Priorities, FY 2004–2009:

- Automate quarterly and annual compilation of fisheries statistics and annual reports on FMP fisheries.

- Develop and maintain web-based coastal salmon abundance database.

- Advance approaches of data fusion to combine fisheries data and assessment model outputs with environmental data from ship, satellite, and physical models.

- Coordinate HMS data organization and data sharing between the Pacific Islands and Southwest Regions and the Pacific Islands and Southwest Science Centers.

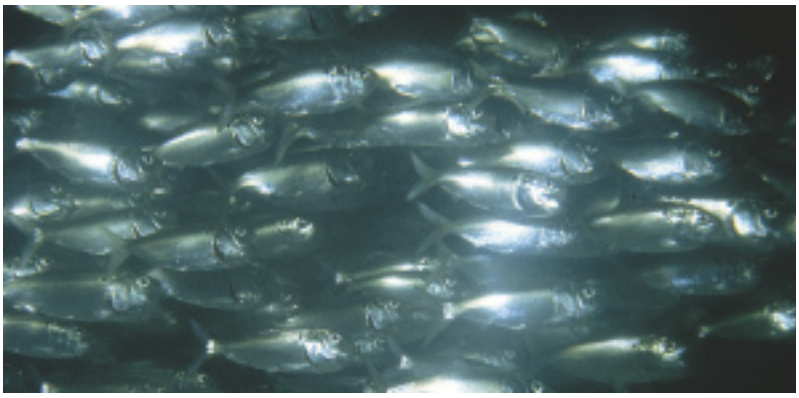
Southeast Fisheries Science Center (SEFSC)

The Southeast Fisheries Science Center (SEFSC) with headquarters in Miami, FL, implements and manages a multi-disciplinary science and research program that provides technical information for conserving and maintaining the sustainability and health of living marine resources and their environments. SEFSC is responsible for the eight southeastern states, Puerto Rico, and the U.S. Virgin Islands, and research is conducted at laboratories located in Miami, FL; Panama City, FL; Beaufort, NC (a joint NOS-NMFS facility); Galveston, TX, with a lab facility in Lafayette, LA; and Pascagoula, MS, with a field station at the Stennis Space Center. There are also numerous field offices providing additional information for research along the coast of the southeastern United States. SEFSC has two fishery research vessels berthed at Pascagoula, Mississippi: the NOAA vessels *Oregon II* and *Gordon Gunter*, as well as numerous smaller research craft located at individual laboratories. In general, SEFSC develops the scientific information required for: 1) fishery resource conservation, 2) fishery development and utilization, 3) habitat conservation, and 4) the protection of marine mammals and endangered species. Impact analyses and environmental assessments for fishery management plans and international negotiations are also prepared, and research is pursued to address specific needs in population dynamics, fishery biology, fishery economics, engineering and gear development, and protected species biology. SEFSC's current staffing level is 272 FTEs, with all positions involved in MSFCMA-related activities. Approximately 80% of all SEFSC resources are devoted to MSFCMA activities.

Each SEFSC laboratory is responsible for conducting research in specific subject areas and also tend to have specific geographic focuses, however, there is extensive cooperative research between SEFSC laboratories. Research activities conducted by the various laboratories are as follows:

Beaufort Laboratory:

Conducts research on biology and fishery for reef fish, including headboat landings, fishing effort, age and growth, reproduction, and assessment of abundance, to support the management of territorial sea, EEZ, and highly migratory resources. Conducts research on processes affecting the distribution, abundance, and use of natural and restored habitats by fishery organisms, and develops techniques and methodologies to evaluate natural and anthropogenic impacts on fishery organisms and their habitat. The program also supports conservation and recovery efforts through evaluations of marine protected areas and also provides scientific recommendations to Fishery Management Councils. Carries out NMFS' mandates for the recovery and conservation of protected species under the MMPA, the ESA, and related legislation.



A dense aggregation of menhaden. Photo: W. F. Hettler, NMFS.

Miami Laboratory:

Performs stock assessments for species such as snapper-grouper, mackerels, highly migratory species (e.g., sharks, swordfish, tunas, and billfish). Scientists also collect and analyze: 1) catch and effort data and 2) scientific information under the Fishery Observer Program for addressing issues such as bycatch of protected species, the assessment of bycatch mitigation techniques and discard mortality of targeted species; supports cooperative research science projects with constituents, states, and local governments; conducts economics and social science research to evaluate the socioeconomic impacts of existing and proposed fishery management actions.

Implements research to support the conservation and recovery of depleted, threatened, and endangered species of marine mammals and sea turtles by: conducting species-population assessment surveys; research on stock structure including genetics, radio tagging, photographic identification, and morphological studies; assessing strandings and unusual stranding events.

Performs research on: “no-take” marine reserves as a fishery management tool to support sustainable fisheries and protect marine biodiversity; ecosystem structure and function; coral reefs, essential fish habitat; habitat restoration; the effectiveness of artificial reefs; and fishing gear effects on populations and habitat; biological research to support stock assessments; fishery-independent assessments; early-life history and early-life ecology of southeastern species.

Conducts research to ensure that coastal ecosystems are improved and are not harmed by the Comprehensive Everglades Restoration Project, which will modify freshwater inflow to estuaries and nearshore areas in southern Florida.

Panama City Laboratory:

Conducts research in the following areas: fishery biology, life history, recruitment dynamics, ecology, essential fish habitats, and fisheries for economically important reef fishes, coastal pelagic fishes and sharks; gear selectivity patterns; impacts of fishing gear on bottom habitats; coral reef research; and ecosystem studies. Monitors certain fisheries for their impacts on whales and sea turtles, and conducts stock assessments and population modeling. Documents the extent and nature of reef habitat and economically important reef fishes within marine reserves.

Mississippi Laboratories:

Develop fishery-independent estimates of reef fish abundance; conduct annual trawl surveys to monitor the status of fish and invertebrates; assess the abundance and distribution of coastal sharks; implement endangered species research; con-

duct visual and acoustic assessment surveys of cetacean stocks; conduct research and development for Turtle Exclusion Devices (TEDs), Bycatch Reduction Devices (BRDs), and longline interactions. Perform environmental remote sensing; and distribute CoastWatch / OceanWatch operational data.

Galveston Laboratory:

Conducts research on: essential fish habitats and the use of landscape techniques to identify Essential Fish Habitat by integrating GIS tools into assessments of habitat value; habitat modifications caused by sea level rise, subsidence, changes in freshwater inflow, coastal eutrophication, and broad scale hypoxia; habitat restoration research; wetland restoration; and ecosystem models for estuarine and coral reef systems. Conducts research to determine, monitor, and describe shrimp population characteristics. Monitors bycatch on shrimp trawl vessels using fishery observers and turtle and marine mammal interactions during petroleum platform removal operations. Conducts captive rearing of loggerhead sea turtles for use in turtle excluder device (TED) certification trials and other fishery-related studies (e.g., turtle responses to longline fishing gear).

SEFSC provides scientific support for NMFS' fishery management activities for the South Atlantic Fishery Management Council (SAFMC), the Gulf of Mexico Fishery Management Council (GMFMC), and the Caribbean Fishery Management Council (CFMC) that involve 17 fishery management plans covering the following major fisheries: spiny lobster, snapper-grouper, reef fish, red drum, coastal migratory pelagic species, coral, shrimp, stone crab, queen conch, and golden crab. SEFSC also has significant interactions with the Gulf States Marine Fisheries Commission (GSMFC), which administers the Fisheries Information Network (FIN) statistics effort; and the Atlantic States Marine Fisheries Commission (ASMFC), which administers the ACCSP and exercises fishery management responsibilities through the Atlantic Coastal Fisheries Cooperative Management Act. In addition, SEFSC maintains close ties with state fishery programs and has funded the State / Federal cooperative statistics program since 1983. Researchers at the SEFSC collaborate extensively with other Federal agencies and academia.

Internationally, the SEFSC provides scientific support for U.S. participation in: 1) the International Commission for the Conservation of Atlantic Tunas (ICCAT), which manages Atlantic Ocean-wide fisheries for tunas and billfishes; and 2) the International Oceanographic Commission for the Caribbean (IOCARIBE), which coordinates fishery oceanography studies among the approximately 30 islands and continental countries in the region. SEFSC scientists also work jointly with the government of Mexico on projects of mutual interest in the Gulf of Mexico under the MEXUS-Gulf research working group.

Constituents have the opportunity to provide input to SEFSC's research programs through representation on FMCs, participation in Council public hearings, and service on Council advisory committees. Input to the SEFSC research program is also received via the activities of interstate fishery commissions (the Atlantic and Gulf States Marine Fisheries Commissions), joint agency planning groups, and cooperative programs with state fishery agencies (GulfFIN). SEFSC responds

to the information needs of fishery management councils and has a formal procedure (Council Operations Plan) for matching its research program to fishery management plan requirements.

SEFSC's high caliber of research is maintained through periodic program reviews by teams that include officials from industry, councils, state agencies, universities, and other constituents. The Center also works diligently to be responsive to the results of program reviews.

RECENT ACCOMPLISHMENTS AND RESEARCH PRIORITIES FOR FY 2004–2009

I. Research to Support Fishery Conservation and Management

Recent Accomplishments:

SEFSC has been instrumental in the development of the improved FMC-led Southeast Data Assessment and Review (SEDAR) process for conducting stock assessments. SEDAR emphasizes constituent / stakeholder participation and an independent scientific review of stock assessments, and benefits greatly from the expertise of existing stock assessment-related committees and panels of Councils and Commissions.

SEFSC has successfully incorporated "risk assessment," "uncertainty," and the new SFA guidelines on "overfished" and "overfished status" into stock assessment methodologies for numerous species in the Gulf of Mexico, Atlantic, and Caribbean.

The development of the red snapper rebuilding plan was based on SEFSC scientific efforts.

The Center is recognized for its expertise in the fields of habitat research and restoration and has successfully developed criteria to define and assess areas of EFH.

SEFSC completed baseline data collection essential for the successful establishment of marine reserves in the Tortugas region for the Florida Keys National Marine Sanctuary and for the Dry Tortugas National Park.

SEFSC has conducted a worldwide review of the nursery value of salt marshes for fishery species in comparison with other estuarine habitat types.

Research Priorities, FY 2004–2009:

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

- Understand and model the linkages between habitats, environmental characteristics, and fishery productivity.

- Develop innovative techniques to assess genetic diversity and habitat utilization of managed fish and invertebrate stocks.

- Develop and maintain high quality fishery-dependent and fishery independent long-term data sets for stock assessments. A main component of this effort will be the expanded use of at-sea observers on commercial and recreational fishing vessels to report on catch and bycatch. Emphasis will be on collecting a wide range of information, including biological and environmental data, gear type deployed, and method of deployment.

- Incorporate marine ecosystems data into conceptual models of food webs to link habitat to productivity and increase the Center's ability to survey, inventory, and understand the dynamics of marine systems and their biota.

- Continue to assess and monitor protected finfish species (e.g., goliath grouper and Nassau grouper).

- Conduct research on HMS stocks, particularly in the areas of stock identification, life history, and precautionary approach methodologies.

- Develop basic life history information and conduct assessments on fish stocks in support of management for the Councils (SAFMC, GMFMC, and CFMC) and Commissions (ASMFC, GSMFC).

- Improve the effectiveness of fishery resource management programs by refining the definition of stocks (including the "management unit" within species).

I.B. Social and economic factors affecting abundance levels

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

I.C. Interdependence of fisheries or stocks of fish

- Evaluate the catch of nontarget species by recreational and commercial fisheries, using applicable programs including the observer program, particularly in cases where the population status of nontarget species, and the community dynamics of important southeast U.S. marine ecosystems, stand to be impacted.

- Increase our understanding of the interactions of protected species (e.g., sea turtles, marine mammals: bottlenose dolphin and large whales) and finfish candidate species (e.g., goliath grouper and Nassau grouper) with ongoing fisheries in the Southeast Region.

- Prevent the extinction and promote the recovery of marine species and at-risk populations through interventions and the continued development of recovery strategies.

Shrimp trawlers in Florida. Photo: William B. Folsom, NMFS.

- Develop scientific methodology for multi-species or ecosystem approaches towards the management of fishery resources, and where appropriate, transition from single-species approaches.

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

- Define and characterize EFH and develop an understanding of natural and anthropogenic threats.

- Develop mapping techniques for more precise positioning of boundaries and for evaluation of fishery values of existing and proposed marine reserves.

- Investigate downstream and coastal impacts of agricultural and urban activities and provide the technical basis for designing and implementing programs for ensuring sustainable coastal communities.

- Gain a better understanding of the structure and function of estuarine, coastal, and marine systems to enhance the conservation and restoration of wetland, benthic, and aquatic areas of EFH.

- Explore innovative techniques to determine the functional value of natural habitats and to evaluate the restoration success relative to the fish community rather than solely to the plant community.

- Develop restoration techniques for EFH including corals, salt marshes, and seagrasses; and determine whether habitats created or restored with such techniques are ecologically functional.

- Integrate EFH research with stock assessments to develop an ecosystem approach for managing fisheries.

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

- Continue to engage in joint efforts with state and other Federal agencies to restore the ecological integrity and water quality in regional estuaries upon which fish depend.

- Continue research efforts under the South Florida Restoration Effort, particularly in the areas of modeling fishery dynamics, recovery of protected resources, restoring EFH,

- Determine the impacts of fishing on reef fish population structure, genetic diversity and resilience.

- Derive more accurate assessments of fishing and other anthropogenic impacts on living marine resources by incorporating risk and uncertainty into models used to predict natural living marine resource variations.

- Develop techniques and scientific data necessary to support the effective application of precautionary approaches to fisheries management.

- Continue to evaluate the efficacy of marine reserves, no-take and limited-take zones, and time closures as fishery management tools.

II. Conservation Engineering Research

Recent Accomplishments:

Innovative approaches to BRD design have been developed. For example, SEFSC has conducted in-situ observations of red snapper behavior during shrimp trawling to aid in the design of more effective BRDs and has successfully led efforts to significantly reduce the bycatch of nontarget species such as red snapper in the Gulf of Mexico shrimp fishery.

The development and use of improved TEDs is contributing to the recovery of sea turtles, especially Kemp's ridley in the southeastern region.

A recovery model for impacted subtropical seagrass habitats was developed and has been used successfully in court to demonstrate impacts to sanctuaries.

Research Priorities, FY 2004–2009:

- Continue investigations on the importance of environmental cues in the spatial orientation and migration behavior of sea turtles.

- Develop and test new gear technology and fishing techniques to minimize bycatch. The SEFSC continues to explore options to reduce bycatch and mitigate mortality of sea turtles and other nontarget species captured in the distant water longline fisheries.

- Develop and test new gear technology and fishing techniques to minimize adverse impacts on EFH. The Center will continue to document the extent and assess the impact of various fishing gears on EFH in support of conservation and management activities.

- Promote efficient harvest of target species. The Center will conduct investigations into limited access options (e.g., individual transferable quotas (ITQs)) as resource management alternatives that aid increased harvest efficiency are continuing.

III. Research on the Fisheries

Recent Accomplishments:

Economic information, analyses, and evaluations were provided for numerous proposed fishery management actions in the southeast.

SEFSC developed and assisted in the collection of economic data through special surveys of the commercial snapper-grouper and mackerel fisheries.

SEFSC, in conjunction with academic economists, contributed to the development of random utility and contingent valuation models of the South Atlantic and Gulf of Mexico recreational fisheries.

SEFSC developed and implemented socioeconomic data collection programs in the Atlantic snapper-grouper and Caribbean fish trap fisheries.

SEFSC hired two additional economists and an applied anthropologist to improve its research capabilities in the social sciences

Research Priorities, FY 2004–2009:

III.A. Social and economic research

- Design and implement procedures to collect socioeconomic data on a routine basis. Data would be used to better determine the effects of regulation on commercial and recreational fishers.

- Develop better models of commercial and recreational fisheries to evaluate proposed management alternatives, including limited access systems.

- Estimate economic relationships such as demand curves, production functions, import supply curves, and recreational benefit functions needed to support the evaluation of management decisions.

- Collect sociocultural data and develop analyses to describe the effects of fishery regulation on the lifestyles, social networks and communities and recreational fishers and other users of living marine resources.

III.B. Seafood safety research

- Support research aimed at identifying and characterizing marine pathogens, especially viruses, in aquaculture shrimp products, and the extent of viruses in wild shrimp stocks.

- Continue to develop biological and chemical analytical methods for toxic contaminants (e.g., mercury), assess their presence in seafood, and define their impacts on marine ecosystems.

- Improve methods to detect, forecast, and evaluate the ecological significance of harmful algal blooms and their impact on fish stocks, marine mammals, and other protected species.

III.C. Marine aquaculture

- Develop the scientific foundation and technical guidelines for establishing ecologically responsible marine aquaculture.

- Continue to investigate the natural occurrence of shrimp viruses.

IV. Information Management Research

Recent Accomplishments:

SEFSC has developed and implemented a fully integrated Oracle-based fisheries logbook system.

Research Priorities, FY 2004-2009:

- Develop a fishery database and information management system that will allow the full use of information in support of effective fishery conservation and management.

- Fully integrate the logbook system with the regional permit database.

- Increase collection of observer-based data on bycatch and improved fishery-dependent data (e.g., via ACCSP's program with ASMFC).

- Secure access by constituents and the public to SEFSC information resources via web-based technologies.

Northeast Fisheries Science Center (NEFSC)

The Northeast Fisheries Science Center (NEFSC) has facilities in Woods Hole, MA; Narragansett, RI; Milford, CT; Sandy Hook, NJ; and supports staff at the National Systematics Laboratory (housed at the Smithsonian Institution in Washington, DC). The NOAA R/V *Albatross IV* and NOAA R/V *Delaware II*, berthed in Woods Hole, MA, support the majority of the Center's fisheries survey and research cruises. Periodically, the NOAA R/V *Gordon Gunter* and NOAA R/V *Oregon II* (berthed in Pascagoula, MS) are utilized as supplemental sources for either surveys or research cruises. Private fishing vessels and academic research ships have been utilized on a periodic basis to support ecosystem surveys on the northeast continental shelf. Two former Coast Guard Buoy-Utility Stern Loading (BUSL) vessels are being converted into inshore research vessels and will be used by the James J. Howard Marine Science Laboratory (R/V *Nauvoo* replaces R/V *Gloria Michelle*) and Milford Laboratory (R/V *Victor Loosanoff* replaces R/V *Shang Wheeler*). The R/V *Gloria Michelle* has been transferred to New Bedford, MA, to support cooperative research between NEFSC, Massachusetts Division of Marine Fisheries, and the University of Massachusetts School of Marine Science and Technology (SMAST).

The NEFSC research activities runs the gamut from stock assessments on finfish populations during the Spring and Fall Bottom Trawl Surveys (conducted annually since the 1960s) to process-oriented research projects such as studying the impacts of global climate change on the coupling of zooplankton/cod and haddock larvae distribution and predation on Georges Bank. Additional fisheries surveys are conducted for ocean quahogs, surf clams, and sea scallops, and grant funds are provided to support surveys of Gulf of Maine northern shrimp and finfish surveys in state waters. The Milford Laboratory conducts aquaculture research on molluscs and finfish, develops algal cultures as a food supply for molluscs, investigates harmful algal blooms (HABs) which pose a seafood safety threat, and investigates field stock enhancement approaches for bay scallops.

Long-term changes in the ecosystem supporting fisheries are monitored through surveys of the Northeast Shelf Large Marine Ecosystem (LME), and research is underway to convert such data into indices on the health of the ecosystem. Additional process-oriented research projects focus upon the effects of pollution on winter flounder; recovery of herring and Atlantic mackerel populations; trophic interactions between Atlantic mackerel, juvenile cod, and haddock; biological characteristics of selected shark species in the Northeast; recruitment processes of bluefish; effects of pollution on bluefish; fishing mortality of bluefish; field investigations on the effects of trawling on seabed habitats; and descriptions of Essential Fish Habitat (EFH) for most coastal finfish species. The Center also conducts social and economic research in support of the fishery management process. The National Systematics Laboratory (NSL) provides taxonomic expertise on finfish, crustaceans, and squids.

Reliable information, critical to the development of regional Fishery Management Plans (FMPs) and subsequent amendments, and, ultimately, to the building and maintenance of sustainable fisheries, is produced through the Northeast Regional SAW process. This process is a cooperative effort of the NMFS / NEFSC and Northeast Regional Office (NERO), NEFMC, MAFMC, and the Atlantic States Marine Fisheries Commission (ASMFC). In the northeast, peer review of stock assessments is conducted twice per year within the Northeast Regional SAW process. The SAW process is guided by the SAW Steering Committee (directors of NEFSC and NERO, MAFMC, NEFMC, and the ASMFC), which determines the species to assess during a particular SAW cycle and establishes the assessment terms of reference. Each SAW cycle begins and ends with the meeting of the SAW Steering Committee and includes Working Group meetings (where analyses are prepared for review); a five-day Stock Assessment Review Committee (SARC) meeting (where analyses are peer-reviewed and advice for managers is developed); and a two- to three-session Public Review Workshop held during planned meetings of the MAFMC, NEFMC, and ASMFC. Participants in this process include NMFS scientists and managers; representatives from fishery agencies outside the region; MAFMC, NEFMC, and ASMFC representatives; state fishery agency representatives from within the region; academic and NGO participants; industry members; and occasionally experts from the international community. SAW meetings are open to the public and are widely announced. NEFSC personnel also participate in various committee meetings of the Regional FMCs and the ASMFC.

The NEFSC Woods Hole Laboratory.

Much of the recent gear research in the northeast has been accomplished through grants, with NERO oversight. These grants have gone to fishers, or to organizations such as states and universities, which carry out the research with the help and cooperation of the fishing industry. The NERO Fisheries Engineering Group is also involved with data analysis for exempted fishery permits and fishway engineering for anadromous fish. Conservation engineering activities in the NERO have recently been concentrated on the problem of entanglement of large whales in fixed fishing gear (e.g., lobster traps and gillnet gear). The fishing industry aided this effort through its participation in the Gear Advisory Group to the Atlantic Large Whale Take Reduction Team to devise solutions, and by volunteering vessels and time for observations and testing. Also, NERO and the Center are collaborating on experiments using pingers and acoustic reflective nets as deterrents to marine mammal entrapment in gillnets. Cooperative research between the fishing industry, NEFSC / NER, and academia extends beyond gear research to include the evaluation of the efficiency of the Center's surf clam / ocean quahog hydraulic dredge, supplemental surveys to the NEFSC bottom trawl surveys, col-

lection of socioeconomic information on commercial / recreational fishing operations, and gathering data on fish migration (tagging) and bycatch using commercial / recreational vessels. Dr. Michael Sissenwine gave a presentation to the House Committee on Resources on cooperative research in the Northeast as a national model.

RECENT ACCOMPLISHMENTS AND RESEARCH PRIORITIES FOR FY 2004–2009

I. Research to Support Fishery Conservation and Management

Recent Accomplishments:

Rates of growth, development, and survival have been estimated for the larval goosefish.

Data have been gathered on the timing and location of goosefish spawning.

Rates of growth, development, survival, and how these vary with water temperature, have been estimated for the egg, larval, and juvenile stages of summer flounder and winter flounder.

The NEFSC has demonstrated that the technique of using scale texture for sexing winter flounder is invalid.

Winter flounder courtship and spawning behavior has been described relative to estuarine habitats.

Measures of egg quality and parental effects on offspring condition have been quantified for summer flounder and winter flounder. The influences of the timing and location of spawning of summer flounder on offspring fitness have been estimated.

Fieldwork in the U.S. GLOBEC program on Georges Bank has been conducted. The program is investigating the environmental and biological processes controlling the reproductive success of the cod and haddock stocks on the Bank.

Development of a micro-constituent technique for stock identification of bluefin tuna and other species was completed.

NEFSC demonstrated that diet influences otolith micro-constituent composition in young-of-the-year bluefish.

The oceanographic conditions on the Northeast Shelf were measured and the interannual variability was documented in a report each year. The data were used in stock assessment activities and available to the scientific community via the World Wide Web.

Ocean current flow field models developed during GLOBEC studies on Georges Bank have been utilized to derive graphic user interfaces for models to track movement of eggs and larvae of commercially important species. The models predict retention and dispersion of developmental stages and facilitates our ability to forecast stock recruitment, as presented at the AGU Ocean Sciences Meeting in January 2004.

A particle tracking model, using both the observed winds and egg distribution from monthly (January–June) ichthyoplankton (1995–1999) surveys, demonstrates seasonal loss of cod and haddock eggs consistent with the calculated egg mortality rates. The model indicates that both the interannual variability in the winds and in the egg distributions are important in determining recruitment of haddock, as presented at the AGU Ocean Sciences Meeting in January 2004.

Six shelf-wide surveys of ecosystem conditions from Cape Hatteras to the Gulf of Maine were completed along with monthly continuous plankton recorder transects of the Gulf of Maine and across the Mid-Atlantic Bight using ships of opportunity in cooperation with NOAA's Global Ocean Observing Program. This contributes to our understanding of the role of plankton for fish recruitment and demonstrates the success of the program.

NEFSC completed a study of diets of 16 fish species in lower Hudson-Raritan Estuary, as compared to other Middle Atlantic areas.

NEFSC completed the second year of a sampling program in the inner New York Bight and lower Hudson-Raritan estuary studying the effects of environmental/habitat variables on settlement and early post-settlement processes of local fish species.

First estimates of rates of hooking mortality for bluefish are being completed.

Effects of sediment contamination on predator-prey interactions are being completed.

A fundamental pattern of lipid accumulation during the estuarine development of inshore-offshore migrating fish was identified and now provides a basis for understanding effects of habitat quality on potential fitness for successful migration and overwintering, as presented at the 25th Larval Fish Conference, August 2001; the scientific publication is under review.

It was shown that there is an increase in susceptibility of lobsters to pathogens under the biogeochemical stressors of hypoxia, sulfide, and ammonium found in estuaries with degraded habitat quality. This information, as presented at the Long Island Sound Lobster Workshop, January 2003, and at the Third LIS Lobster Health Symposium, March 2003, may help us to understand the causes for recent mass mortality of lobster in the northeast.

Several presentations have been made on the effects of bottom trawling on the seabed at Georges Bank.

Tautog, *Tautoga onitis*, in the Rarragansett Bay National Estuarine Research Reserve. Photo: NOAA.

Surveys collecting in-situ video observations of the sea floor and conducting trawls in the mid-Atlantic Bight have been useful for assessing the effects of bottom trawling on tilefish habitat.

Hydroacoustic survey techniques have been developed for pelagic fish species and are being used in stock assessments for Atlantic herring.

The NEFSC Fisheries Observer Program conducted detailed monitoring of pound nets in Chesapeake Bay during the spring of 2002 and 2003 for sea turtle entanglements. After monitoring nets in the entire Bay, areas of great concern were identified by recording 7 entanglements in 2002 and 17 in 2003. This research has led to management actions to prevent further mortality of endangered and threatened sea turtles.

Bigelow and Schroeder's *Fishes of the Gulf of Maine*, edited by Bruce B. Collette and Grace Klein MacPhee, was published by Smithsonian Institution Press.

Ground Fish Assessment Review Meeting (GARM) was held in October 2002 to review the trawl warp impact on the resource surveys aboard the R/V *Albatross IV* from Winter 2000 to Spring 2002.

Twelve Center scientists and six outside experts released a summary report that reevaluated the potential growth, achievable population sizes, and sustainable fishing rates for major groundfish stocks in the Northeast (to address shifting baseline phenomena).

In February 2003, an external peer review was conducted on the NEFSC's stock assessment approaches as a prelude to developing Amendment 13 for the Multispecies Groundfish FMP.

In 2001, the report "Marine Angler Expenditures in the Northeast, 1998" estimated $4.5 billion in recreational fishing equipment and trip expenditures by saltwater anglers in ten northeastern states.

In 2001, the new Fisheries Scientific Computing System (FSCS) was introduced on our fisheries research vessels (*Albatross IV* and *Delaware II*) which provided researchers immediate access to our survey data.

NEFSC scientists participated in the History of Marine Animal Populations

(HMAP) project which was funded by a $1.2 million grant from the Alfred P. Sloan Foundation in New York. This project contributes to the Census of Marine Life (CoML) program.

Biological parameters that potentially regulate foraging competition in juvenile bluefish and striped bass were identified.

A series of 30 EFH Source Documents, summarizing life history, habitat, and distribution / abundance information, was provided to NEFMC and MAFMC.

A study of functional equivalence of marshes replanted after EXXON Bayway Oil Spill in Arthur Kill (NY / NJ) to oiled, but unrestored, marshes and control marshes was completed.

The potential predation risks of juvenile summer flounder and winter flounder in inshore habitats were quantified.

NEFSC demonstrated that nominal habitat classifications are inadequate for defining and studying the functional value of those habitats.

NEFSC has conducted studies which demonstrated that habitats are dynamic, defined by complex interactions of changing environmental conditions, and yielding a space favorable to growth and survival that continually expands, contracts, and changes position.

Environmental conditions and physical habitat within a shallow coastal nursery area in Connecticut that supports young tautog were characterized. The distribution and abundance of these fish has been described and preliminary GIS-based spatial maps have been created. Young tautog have been marked with coded wire tags in an effort, through mark-recapture, to determine individual growth rates, population size, and the extent of site-fidelity. Diets of young tautog and food habits of predators have been investigated. These efforts will be valuable in future attempts to release hatchery-reared tautog as they become available from the Milford Aquaculture Program.

The effects of egg incubation temperatures on the development and survival of summer flounder, winter flounder, windowpane, cod, and haddock have been quantified through laboratory experiments.

A study was completed that indicated that the re-suspension of contaminated sediments is the dominant process in distributing contaminants in the Hudson-Raritan and Navesink estuaries.

The uptake of trace metals and organic compounds into mussels from Arthur Kill sediments, including those tainted by oil spills, was investigated.

NEFSC Ref. Doc. 02-11 on the status of the Northeast U.S. Continental Shelf Ecosystem provided an overview of the results from the NEFSC's monitoring programs / resource surveys and will serve as the base for supporting the Center's

ecosystem-based approach for fisheries management (EbM). A number of peer-reviewed journal publications resulted from this information synthesis endeavor.

A paper published in Limnology and Oceanography described the distribution of chlorophyll (from ocean color) and sea surface temperature (SST) off the Northeast coast that will provide the basis for estimating primary production on the shelf. This will support the EbM program.

Ocean Exploration funding has been utilized to examine deep sea nekton/epibenthic biodiversity at the Bear Sea Mount and Mid-Atlantic Ridge in support of the Census of Marine Life (CoML).

The Rutgers University/NOAA Cooperative Marine Education and Research (CMER) Program has supported research on the effects of bottom roughness on surf clam larval settlement and recruitment.

The University of Massachusetts/NOAA CMER Program has supported research on the use of living marine resources (LMRs) for subsistence utilization and the entry points for heavy metal contaminants into the marine food chain.

Research Priorities, FY 2004–2009:

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

- Increase precision of biological parameter estimates by incorporating new information on growth rates in recovering populations.

- Determine biological, environmental, and habitat processes controlling the reproductive success of important fishery resources.

- Expand research in the development of micro-constituent chemical analysis techniques for stock identification.

- Continue and expand cooperative research activities with the fishing industry to routinely collect environmental and biological data for improved monitoring of the ecosystem.

- Transition biophysical models developed as part of research programs to operational tools for use in support of management decisions.

- Continue field and modeling research activities to better understand the influence of environmental variability on lower trophic level productivity and fish recruitment.

- Conduct studies to document and understand the behavior and movement of fish in areas of critical habitat.

- Continue to monitor oceanographic and biological conditions on the North-

east Shelf and document ecosystem variability in order to determine its role in the recovery and sustainability of depressed fish stocks.

- The NEFSC is developing a pilot project for an ecosystems-based fisheries management approach based upon the observed shift in the early 1980's from a demersal-dominated fish community to a pelagic-dominated community.

- The Hydroacoustics Team will develop acoustic scattering models to improve population estimates and examine the applicability of advanced technologies, such as broadband and multibeam acoustic systems.

- Cooperative research tagging projects for black sea bass in the Southern New England (SNE) and Mid-Atlantic Bight (MAB) areas and cod in the Georges Bank (GB) / Gulf of Maine (GOM) regions will expand our knowledge of fish migration and demographics for these species.

- An outgrowth of the GARM workshop was the creation of a joint NMFS / Industry committee to provide oversight for the bottom trawl resource surveys.

- An outgrowth of the stock assessment peer review is continuing investigations of the appropriate assessment methodologies for GB / GOM cod stocks and SNE winter flounder and the appropriate uses of Ricker stock-recruitment models.

I.B. Social and economic factors affecting abundance levels

- The UMass / NOAA CMER Program is supporting a new research project on the factors constraining recreational fishing activities.

I.C. Interdependence of fisheries or stocks of fish

- The bluefish / striped bass interaction project for the Mid-Atlantic Bight (MAB) has embarked upon a new research direction to understand bluefish dynamics at large spatial scales in order to support management / user information needs. This effort is coordinated by the Rutgers / NOAA CMER Program.

- Ocean exploration funding will continue cruises for delineating deep sea biodiversity of nekton.

- Completion of Large Marine Ecosystem (LME) volumes will continue and website / maps will be updated.

- Completion of manuscript on decadal changes in ocean color measurements on the Northeast Continental Shelf using the CZCS and SeaWiFS satellite sampling periods.

- UMass / NOAA CMER Program is supporting a new project examining sea scallops / starfish predator-prey interactions on Georges Bank.

Lobster traps, Boothbay Harbor, Maine. Photo: William B. Folsom, NMFS.

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

- Identify and provide EFH information as required by the MSFCMA for FMPs.
- Continue to conduct research to determine the functional value to estuarine and nearshore habitats, including restored sites, to the sustainability of fishery resources.
- Continue to improve our GIS capabilities in order to map seabed habitats and indicate EFH with respect to various human-activities.
- The Rutgers/NOAA CMER Program Director has received extramural grant support to examine the bio-availability of dissolved organic nitrogen (DON) to help elucidate its role in coastal eutrophication. A biocomplexity grant from the National Science Foundation is being used to examine the bottom-up and top-down processes controlling the microbial degradation of organic matter in estuarine sediments.

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

- Conduct research to determine the effects of climate variability on the sustainability of coastal and pelagic fishery resources.
- Investigate the transfer of contaminants within estuarine systems and their effect on the growth and sustainability of fish populations.
- Continue to investigate the effect of fishing activities on seabed habitats and EFH.

II. Conservation Engineering Research

Recent Accomplishments:

Through the recently established NEFSC Office of Cooperative Programs Coordination, approximately 1,600 research fishing days were conducted since the program's inception in September 2000. This multifaceted program is designed to explore ways to improve data upon which fishery management decisions are made as well as to improve communications between fishers, scientists, and fisheries managers. One of the key elements of this program is in the area of conserva-

tion research (i.e., mesh selectivity, bycatch discard reduction, harvest efficiency, and gear development).

The NEFSC Fishery Observer Program has made recent strides in the development and deployment of more selective fishing gears by placing scientific observers aboard commercial vessels. Specifically, in the Gulf of Maine northern shrimp fishery, the Nordmore grate was tested and subsequently implemented as a method to reduce the take of juvenile groundfish. Sea sampling was used in the initial gear trials, and the at-sea observer program continues to monitor the fishery following full implementation of the grate requirement. The fishery observer data indicate significant reductions in finfish bycatch after introduction of the Nordmore grate in the shrimp fishery. Although reduced catches of important groundfishes are in part due to their decreased abundance in recent years, the grate has been effective in reducing the fraction of finfish caught in this fishery, thereby reducing fishing mortality on young groundfish.

Similar studies evaluating the effectiveness of acoustic alarms to deter harbor porpoise from entering groundfish sink gillnets have also been conducted through the Fishery Observer Program. These studies involved alarm-equipped and control nets, fished in the vicinity of harbor porpoise aggregations. Results from this work are currently being evaluated to determine the efficacy of this method in reducing harbor porpoise mortalities. Additionally, at-sea observers have been used in other gear-related studies such as in the New England groundfish fishery to evaluate the effectiveness of changes in trawl mesh size.

Center scientists are also involved with the development of gear-based solutions for the reduction of sea turtle takes in commercial fisheries. Two projects are currently underway, including the use of a chain mat on scallop dredges to reduce turtle bycatch in the scallop fishery and the development of a turtle-proof whelk pot to reduce entanglements. Both of these projects are cooperative efforts with industry and the Virginia Institute of Marine Sciences. A third cooperative project to develop turtle-safe pound net leaders is in the development stage.

Research Priorities, FY 2004–2009:

- Conduct research to develop and enhance gear performance and characteristics.
- Conduct research aimed at reducing bycatch and marine mammal mortalities.
- Conduct studies to evaluate the effects of gears on habitats.

III. Research on the Fisheries

Recent Accomplishments:

The NEFSC has recently completed development of a New England-wide Input-Output model in collaboration with the Woods Hole Oceanographic Institute's

Marine Policy Center. This model is used to assess distributional impacts of fisheries regulations.

The NEFSC conducted collateral research with the Massachusetts Institute of Technology's Center for Marine Social Sciences (CMSS) to collect socioeconomic data on fishers and fisheries-dependent communities.

The NEFSC has conducted Vessel Cost and Earning Surveys for all major fisheries in the region. These "snapshot" surveys contributed to the design of the coastwide pilot program for social science data used by the Atlantic Coast Cooperative Statistics Program (ACCSP). Data collection is now being collected on a continuing basis through the sea sampling program.

The NEFSC has produced a variety of socioeconomic publications on the fisheries to inform resource managers and the public. These works address such issues as property rights, allocations between recreational and commercial fisheries, rent-seeking behavior in fisheries, models of recreational fisheries, tests of fishermen's predictions of management impacts, and estimates of forgone national benefits as a result of shortcomings in the management of groundfish. Additionally, in support of two regional FMCs, the NEFSC has provided RIR / Regulatory Flexibility Act analyses for 17 FMPs and numerous amendments / framework actions.

The NEFSC's Office of Marine Ecosystem Studies has been active in the monitoring and assessment of changes within the U.S. Northeast Shelf ecosystem in relation to the recovery of depleted demersal fish stocks, including cod, haddock, and yellowtail flounder and the unprecedented population explosion of pelagic herring and mackerel stocks.

Several United Nations agencies are collaborating with the NMFS Office of Science and Technology and Fishery Centers to introduce ecosystem-based assessment and management practices leading to the recovery of depleted fish stocks in Asia, Africa, Latin America, and Eastern Europe. A five-module strategic approach developed and tested by the NEFSC has been introduced to coastal countries bordering LMEs of the Yellow Sea (China and Korea), the Benguela Current (Angola, Namibia, South Africa), the Guinea Current (Benin, Cameroon, Ghana, Ivory Coast, Nigeria, and Togo), and the Baltic Sea (Denmark, Finland, Germany, Sweden, Estonia, Latvia, Lithuania, Poland, and Russia). The five modules provide advanced methodologies for monitoring and assessing the: 1) productivity, 2) fish and fisheries, 3) pollution and health, 4) socioeconomics, and 5) governance of the LMEs.

The NEFSC has conducted several studies on the effects of buyout programs in the Northeast regions including an assessment of buyout program effectiveness and improvements in buyout program design.

The NEFSC has provided personnel who organized a national Communities Workshop attended by NMFS and other Federal agency and academic social scientists to explore issues related to National Standard 8 of the 1996 Sustainable Fisheries Act as well as other legally required social analyses such as Social Impact

Assessments. A Sociocultural Practitioners' Manual resulting from this Workshop, coauthored by NEFSC personnel, is in the editing phases.

The NEFSC has provided personnel to create and update content for the Community Impact Analysis page hosted by HQ's Office of Science and Technology. (http://www.st.nmfs.gov/st1/econ/impact.html).

The NEFSC created and analyzed a survey of vessel owners and crew who participated in a buyout, creating a publication that is easily accessible to the public by mail or on the web (http://www.nefsc.noaa.gov/read/socialsci/survey-initiative/).

The NEFSC has developed methods for estimating fishing capacity and fishing vessel efficiency which have been used to assess fishing capacity in the Northeast region and were accepted as the standard for capacity measurement in other regions.

The NEFSC has developed math programming models to evaluate effort redirection in time and space in response to regulatory measures that may vary by region or season. This model was used as the primary basis for biological and economic impact assessment for groundfish and has been applied to evaluate essential fish habitat alternatives for several Mid-Atlantic plan amendments.

Grants from the Global Environment Facility have been allocated over the past 5 years to support the LME projects. In each of the LME projects, joint international surveys are carried out measuring the effects of changing ecosystem states on the recovery of depleted fish stocks and the long term sustainability of biomass yields, ecosystem health, and socioeconomic benefits to the coastal communities. Participating countries have created, under the United Nations Convention on the Law of the Sea (UNCLOS), Commissions and other joint institutions to serve as governance bodies and to initiate more sustainable ecosystem-based management protocols than have been generally initiated and practiced during the past half century.

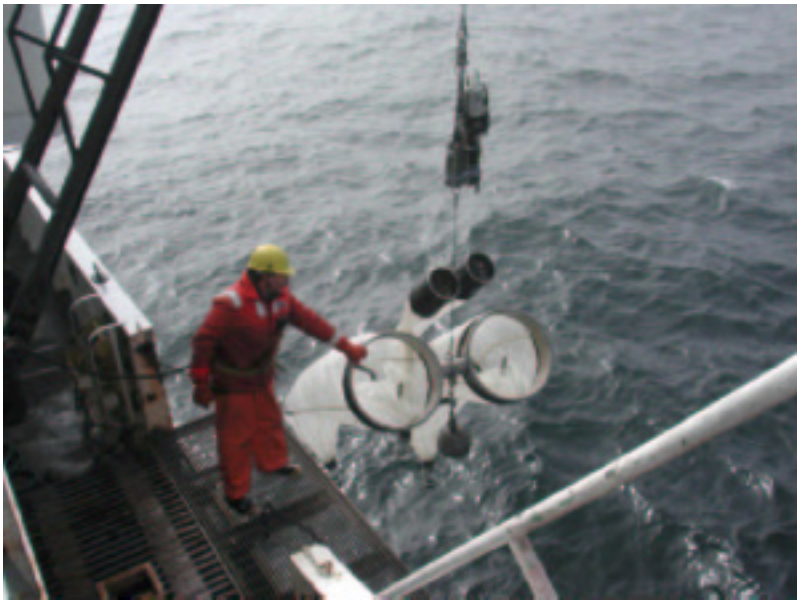
Sampled and characterized nearshore rocky-vegetated and sand habitat types in studies prerequisite to stock enhancement trials with tautog and/or black sea bass.

Developed a genetic line of phenotypically distinct bay scallops with striped shells for stock enhancement trials in the Niantic River.

Completed a yearlong monitoring of scallop larvae, water, and feed for microbial pathogens and provided advice on disease avoidance in aquaculture systems.

Evaluated prevalence of blood-borne bacteria in a cooperative study on caged lobsters in stressed environments.

Co-chaired "Workshop on Domestication of Molluscan Shellfish," with French colleagues, in LaTremblade, France, to develop implementation plan for NOAA-IFREMER Bilateral Agreement on Oceanography project.



A bongo net with Seacat instrumentation being deployed for fish-larval studies.

Co-chaired a Genetics Theme Session with Danish colleagues for the ICES Conference in Copenhagen,

Completed overview of historical accounts of fish kills in coastal New Jersey waters; published findings as NEFSC Reference documents.

Completed development of flow-cytometric methods for evaluation of morphology and function of hemocytes for the eastern oyster, in collaboration with French colleagues; submitted three articles for publication in peer-reviewed journals.

Started new research initiative on use of heterotrophic protists in aquaculture food chains, in collaboration with other Milford personnel and CMER-funded university researchers.

Completed initial exposures of pathogen-infected lobsters to four environmental stressors and analyzed lobster death rates associated with bacterial growth rates. Completed experimental study demonstrating unexpected nutrient limitations in large-scale microalgal cultures and developed strategies to mitigate limiting factors.

Demonstrated for the first time effects of harmful algae upon the cellular immune response of oysters and scallops, in collaboration with French colleagues.

Completed experimental studies of trophic interactions between bivalve and pulmonate mollusks, and toxic *Alexandrium* species, as both vegetative and cyst stages.

In October 2002 the EPA report EPA/600/R-02/079 on the Waquoit Bay Watershed Ecological Risk Assessment project examined the relationship between land use activities on upper Cape Cod, nitrogen enrichment of the bay waters, the loss of eelgrass beds and collapse of the bay scallop harvest.

The University of Rhode Island (URI)/NOAA Cooperative Marine Education and Research (CMER) Program has helped support the Narragansett Bay Cooperative Study Project which examines the physical and biological processes controlling the productivity in the bay.

Research Priorities, FY 2004–2009:

III.A. Social and economic research

- Social science staff will develop a strategic research plan to improve the social science information available to fishery managers. This plan will assess existing sources of data, identify research needs, and determine a strategy for achieving these needs to include a combination of out-sourced and in-house research. Some tasks already underway include:

- Work with area expert to examine the role of Environmental Justice (EO 12898) issues as they relate to fishing communities in the Northeast.

- Work with area experts to identify and explore proactive community-based initiatives that encourage fishery conservation in the Northeast and the role government / fisheries management can play in providing an enabling environment for such initiatives.

- Develop social indicators and minimum data elements to be incorporated into other National and regional efforts, such as the ACCSP database, the observer program and National data collection efforts.

- Work with NMFS headquarters, regional experts, community leaders, and school children to help create a database of traditional knowledge in Maine, as part of a pilot project that may be expanded nationally.

- Continue to develop guidance on National Standard 8 and on social impact assessments (SIAs). This includes examining approaches to rapid assessment techniques and institutions as well as establishing coastal cooperation in the supply of updated information relevant to SIAs on a continuing basis.

- Investigate and develop design features to mitigate perceived failures of individual fishing quota (IFQ), ITQ, and CDQ fishery regulations.

- Continue the development of ongoing coast-wide cost and earnings data collection systems. This research includes the design of a fixed cost sampling protocol and the exploration of wide-scale observer-supplied economic data systems.

- Continue the development of a sociocultural information gathering system sufficient for National Environmental Policy Act, National Standard 8, and SIA requirements for fisheries, marine mammals, endangered species, critical habitat for designated species, and EFH designations.

- Conduct additional research into multispecies management options incorporating various levels of constituent species. Research will focus on differential area treatment of gears, vessels, and effort based on habitat and fishing mortality considerations as well as impacts of variously defined MPAs.

- Conduct further exploration of applicability and utility of GIS information on economic and sociocultural assessments of area-based management options including development of socioeconomic and governance modules for LMEs.

- Continue research efforts for price models, bioeconomic models, rapid social assessments techniques, rights-based fishing modes, annual round fisheries, and other issues central to improving approaches to management and the design and assessment of alternatives. Of particular concern is the coming need for the estimation of non-use benefits and cost minimization research for EFH, ESA, and MMPA issues.

- Extend input-output models to mid-Atlantic states for the management of recreational fisheries.

- Examine the role of the processing sector in New England and mid-Atlantic communities. Research will be used to improve sociocultural data bases as well as refine regional input-output models.

- Integrate NEFSC population dynamics simulators with economic optimization models to examine potentially superior exploitation trajectories for groundfish.

- Develop predictive models of trading of days-at-sea.

- Develop spatial dynamic models to assess optimal design of approaches to essential fish habitat protection including a comparison between piecemeal and zoning approaches.

- Extend previous research on risks at-sea.

- Examine the relationship between fish landings, imports, resource conditions, and processing capacity in New England.

III.C. Marine aquaculture

- Continue the development of the microalgal greenhouse-recirculating seawater nursery system, using technologies currently in place, to identify most critical needs for further development.

- Determine the feasibility of aquacultural pilot-scale hatchery production of black sea bass juveniles and adults.

- Evaluate the potential value of using selectively-bred bay scallops with distinct shell markings in field stock enhancement efforts.

- Determine the importance of unusual sterols in harmful microalgae, in terms of nutritional and toxic effects upon bivalve mollusks and crustaceans.

- Explore the extent to which harmful algal blooms affect the immune system capability of bivalve mollusks and the importance of these effects in the susceptibility of mollusks to environmental, pathogen, and parasite stresses.

- Define the role of nearshore hard-substrate reefs as habitat for young fish.

IV. Information Management Research

Recent Accomplishments:

NEFSC oceanographic data sets are being served through a distributed oceanographic data system (DODS) compliant server. In addition, data collected as part of the U.S. GLOBEC program on Georges Bank are being served through the GLOBEC data system, which is a DODS compliant system.

Research Planning and Coordination (RPAC) Group utilizes Project, Planning, and Tracking (PPT) System for linking planned program activities with accomplishments (milestones and events).

Data Management Systems (DMS) Group developed the PPT System.

RPAC operates an Extramural Proposal Tracking System that informs scientists of funding opportunities and then oversees the endorsement / review process for submitted proposals. RPAC provides an annual report to the Science and Research Directorate on this program.

The Research Communications Unit processes approximately 300 items annually for review and eventual external publication or presentation, handling all internal peer review as well as production of Center and regional level NOAA Fisheries publication series.

Research Priorities, FY 2004–2009:

- Continue to develop and expand DODS compliant client and server libraries to support Internet access to NODC oceanographic data sets.

- Continue ESDIM-funded projects to rescue 106 years of plankton and temperature data collected from 1840 to the present.

- Integrate acoustical data from echo founders with biological and oceanographic data into a relational database with GIS capabilities to support hydroacoustics research program.

- Use PPT system to support information input to Annual Operating (AOP) system, while DMS provides technical support for PPT.

- DMS provides technical support for databases used by Center scientists: FSCS, Biological Sample Monitoring Data Base System (BSMDBS), Scallop Experi-

mental Fisheries Data Base System (SEFDBS), Marine Mammal Stranding Data Base System (MSDBS), Commercial Fisheries Data Base System (CFDBS), Food Habits Data Base System (FHDBS), Observer / Sea Sampling Data Base System (OBDBS / SSDBS), etc.

- DMS converts Center databases to the Oracle Relational Database Management System (RDBMS), including survey databases, food habits database system, and age data entry system.

- DMS will continue working on a commercial fisheries database system (CFDBS) allocation scheme for 1994–1999 commercial fisheries catch / effort data.

- DMS is developing a prototype data set for the ACCSP in an intermediate file transfer format.

- Provide expanded desktop internet access to electronic library and reference materials at all NEFSC facilities.

- Continue recovery of important paper-only NEFSC scientific works in digital format.

Pacific Islands Fisheries Science Center (PIFSC)

The Pacific Islands Fisheries Science Center (PIFSC) conducts multidisciplinary basic and applied research on insular and oceanic pelagic living resources and fisheries of the Pacific Islands and central Pacific. The PIFSC headquarters are located in Honolulu, Hawaii, on the University of Hawaii at Manoa campus. PIFSC has a Honolulu shoreside research facility at Kewalo Basin. These facilities house over 160 people, including Federal employees of the PIFSC and collaborating staff of the NOAA-University of Hawaii Joint Institute of Marine and Atmospheric Research (JIMAR). The primary platforms supporting PIFSC field activities include the NOAA ship *Oscar Elton Sette* and chartered vessels from the commercial industry. Fisheries research activities at the PIFSC support the scientific, statistical, and economic needs of the Western Pacific Region Fisheries Management Council (WPRFMC). They also contribute to U.S. scientific support of international organizations concerned with the management and conservation of tunas, billfishes, and other highly migratory pelagic species (HMS) in the Pacific, such as the emerging Western and Central Pacific Fisheries Commission (WCPFC), and scientific bodies including the Standing Committee on Tuna and Billfish of the Secretariat of the Pacific Community (SCTB) and the Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean (ISC). Collaborative and cooperative research partners include other Federal and State of Hawaii agencies, academic institutions, foreign research institutions, government agencies of American Samoa, Guam, the Commonwealth of the Northern Marianas Islands, and the public sector including the commercial fishing industry, seafood markets, and recreational and environmental interests, including NGOs. HMS research at the PIFSC is often collaborative and coordinated with the SWFSC on a regular and ongoing basis. While not outlined here, a broad range of research focused on protected resources not related to fisheries are also conducted at the PIFSC.

The PIFSC conducts biological, ecological, and economic research on the following fishery resources that fall under active fishery management plans:

- large pelagic fishes of the Pacific Ocean (including tunas, billfishes, sharks, and a number of other incidentally caught but commercially important species)
- crustaceans of the Pacific Islands deep slopes (lobsters and shrimp)
- bottomfish and seamount groundfish of the central Pacific
- precious corals of the central Pacific
- coral reef ecosystems of the central Pacific

In addition, from a marine ecosystem standpoint, all of the PIFSC fisheries programs rely on information about the physical environment in the western and central Pacific Ocean. To this end, satellite remotely sensed ocean and atmospheric data, ocean circulation models, information from research cruises, and fisheries data are used to advance our understanding of the dynamic physical and biologi-

The NOAA ship *Oscar Elton Sette*, which operates out of Hawaii, seen here at Maug Island, CNMI. Photo: R. Schroeder, JIMAR.

cal ecosystems found in the Pacific region.

Organizationally, fisheries research at the PIFSC is generally carried out by four of the Center's research divisions: the Coral Reef Ecosystem Division (CRED), the Ecosystems and Oceanography Division (EOD), the Fish Biology and Stock Assessment Division (FBSAD), and the Fisheries Monitoring and Socio-economics Division (FMSD). The CRED conducts multidisciplinary ecosystem-based research and monitoring that provides the scientific basis for effective management and conservation of coral reef ecosystems in the U.S.-affiliated islands of the central and western Pacific Ocean. Specific research activities include: 1) ecological assessment and monitoring to quantify and document spatial and temporal changes in the health of coral reef living resources due to natural or human-induced impacts; 2) habitat mapping and characterization to define and understand the dynamics of habitat-ecosystem-resource linkages; 3) monitoring of oceanographic processes affecting reefs to monitor conditions that influence coral reef ecosystem health; and 4) reef restoration through the assessment, monitoring, and mitigation of the effects of marine debris on coral reef ecosystems. Complementary applied research include: evaluating the effectiveness of marine protected areas (MPAs), evaluating impacts of fishing gear on essential fish habitat, and improving assessment and monitoring techniques for commercial bottomfish populations.

The EOD conducts research aimed to advance our understanding of the structure and dynamics of marine ecosystems in the Pacific Islands region and the broader North Pacific. Research focuses on: 1) the role of living resources in the ecosystem and 2) how these resources might respond to change, both on the local scale (e.g., predators or prey availability) and on broader time and space scales (e.g., ocean climate change). The EOD's multidisciplinary projects allow for collaborative research with other Center Divisions, agencies, and academia, and address ecosystem, environment, and anthropogenic impacts for a range of species including the Hawaiian monk seal, several species of sea turtles, and highly migratory species including tunas, billfishes, and other incidentally harvested species.

The FBSAD conducts state-of-the art research related to the population biology, stock assessment, ecology, and life history of exploited resources and associated species (e.g., prey, bycatch, and protected species) in the central and western Pacific. FBSAD integrates biological, ecological, oceanographic, and economic data to advance stock assessments and to advise resource management at both species and ecosystem levels while addressing mandates of the MSFCMA, ESA, MMPA, and the Migratory Bird Treaty Act. Research programs emphasize population modeling, resource survey cruises, experimental fishing, determination of vital

rates and other life-history parameters, environmental physiology, distributional ecology, and mitigating fishery interactions with protected species.

The FMSD is the focal point for much of the data collection and economic and operational research for the PIFSC. This Division collects, quality controls, and processes fishery-dependent information (i.e., logbooks), issues quarterly and annual reports (including longline, bottomfish, and lobster), and conducts socio-economic research on Federally-managed fisheries. Also residing in the FMSD is the Western Pacific Fisheries Information Network (WPacFIN) that collects and processes Pacific Islands' agencies data (Territories of Guam and American Samoa, Commonwealth of the Northern Mariana Islands (CNMI), and State of Hawaii) and also provides technical support to develop and implement appropriate data collecting, processing, summarizing, analyzing, and report-generating systems for these island agencies.

RECENT ACCOMPLISHMENTS AND RESEARCH PRIORITIES FOR FY 2004–2009

I. Research to Support Fishery Conservation and Management

Recent Accomplishments:

Several life history studies involving juvenile swordfish, *Xiphias gladius*, have been completed. These studies include an otolith-based age and growth study using scanning electron microscopy (SEM) that will help to corroborate estimates of age-1 individuals derived from anal fin ray cross-sections and a calibration experiment between four international Pacific fisheries laboratories for processing and reading of fin-ray cross sections to determine growth rates. Also completed was a project to assess the ability to detect geographically distinct natal sites of juvenile swordfish in the Pacific using geochemical elemental fingerprinting. These results are a first step in determining our future ability to determine natal origin of adult swordfish based on analyzing the elemental chemistry of the juvenile portion of the otolith.

The PIFSC and the SWFSC have successfully collaborated on a billfish egg and larvae project which has culminated in the ability to identify istiophorid larvae and billfish eggs of all six Indo-Pacific billfish species found in Hawaiian waters. Using genetics (polymerase chain reaction (PCR) identification) techniques developed at the SWFSC and refined at sea on PIFSC research cruises, this technique provides for near-real time identifications while at sea and now allows field researchers the ability to adapt subsequent sampling protocols in order to better define the location, spatial extent, and associated habitat of specific billfish species.

Completed fecundity and size-at-maturity studies for spiny and slipper lobsters in the Northwestern Hawaiian Islands (NWHI) revealing temporal changes in the reproductive traits of spiny lobster. Size-specific increases in fecundity and egg size were observed in the most recent estimates as compared to historical esti-

PAT on a yellowfin tuna. Photo: D. Curran, JIMAR.

mates and fecundity increases were consistent with decreases in median body size at sexual maturity. These findings lend credence to the need to periodically reevaluate the reproductive responses of exploited lobster populations.

Supplemental spiny lobster tagging experiments were continued at Necker Island (ca. 14,000 lobsters tagged) to obtain independent estimates of mortality, growth, abundance, and movement, and to advance population modeling and resource assessments. Feasibility experiments to assess the utility of a stationary underwater camera system to qualify and quantify potential impacts of lobster trapping on coral reefs have also been completed.

Studies on the population status of several HMS were completed that provides up-to-date information for the management of the Hawaii-based longline fishery. Assessments of North Pacific swordfish and blue shark indicate that both populations are sustainable given current fishing pressure; however, a Pacific-wide blue marlin assessment indicates that the population may be close to a fully exploited state.

PIFSC scientists continue research utilizing electronic tags to improve our understanding of the ecological, migratory and post-release survival of longline caught fish. Pop-up satellite archival tags (PATs) have been deployed on blue sharks, bigeye tuna, swordfish, opah or moonfish, and albacore tuna. The PAT technology has provided excellent data on fine-scale vertical movements, and geolocation estimates have pioneered the use of a state-space Kalman filter to estimate light-based geolocation errors, horizontal movement parameters, most probable tracks and residence times.

A recent multilevel economic multi-objective programming model (MMPM) has been developed for the Hawaii fisheries and will be used to analyze the economic impacts of time-area closure policies.

Generalized additive models (GAMS) have been developed using detailed catch and set observations gathered from Pacific Islands Regional Office observer pro-

gram to assess the impact of time-area closure alternatives in the Hawaiian longline fishery. In particular, the models were used to assess the effectiveness of the time-area closure imposed on the longline fishery and are being used in litigation concerning the impact of the Hawaiian longline fishery on sea turtles.

Recently completed analysis on the migration pathways and foraging habitat of loggerhead and olive ridley sea turtles will help in identifying time, area, and gear restrictions that will reduce incidental catches in the fisheries where sea turtles are caught incidentally, particularly the Hawaiian longline fishery for tuna.

Surveys conducted with the National Undersea Research Program's (NURP) Hawaii Undersea Research Laboratory (HURL) submersibles and ROV have enabled description of essential fish habitat for Hawaiian bottomfish and evaluate the effectiveness of bottomfish restricted-fishing areas. These technologies have also supported PIFSC research on the density, size structure, and associated fish assemblages of deepwater coral communities and have led to findings of the ecological importance of deepwater corals as monk seal critical forage habitat.

Baseline ecological surveys of fish, corals, algae, and other invertebrate diversity and abundance have been completed for selected areas of the U.S. Line and Phoenix Islands, American Samoa, and the NWHI, using separate but complementary techniques of Rapid Ecological Assessments (REAs) and towed diver surveys. These surveys also resulted in the first, and extensive, observations of widespread mass coral bleaching in the NWHI.

An acoustic benthic habitat characterization system capable of performing high-resolution mapping in coral reef habitats was developed, providing a very effective means for extending habitat characterization to deeper areas that are not suited to observations by divers or by satellite.

More than 100 tons of marine debris were removed (in summer 2003 alone) by a multi-ship, multi-agency 4-month cooperative effort at Pearl and Hermes Atoll and Midway Island in the NWHI.

Research Priorities, FY 2004–2009:

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

- Conduct peer-reviewed assessments and statistical analyses on stocks of insular and pelagic species.

- Conduct research to better understand the stock dynamics and influence of environmental conditions on pelagic (North Pacific and around American Samoa) and NWHI insular stocks.

- Develop new methods of stock assessment for application to data-poor bottomfish species.

Removing marine debris. Photo: PIFSC.

- Develop a comprehensive insular resource survey using chartered commercial fishing and research vessels for the Hawaiian Archipelago.

- Assess the connectivity of spatially structured insular populations in the Hawaiian Archipelago.

- Develop and implement an international tagging program for HMS in the Pacific Ocean to trace their movements between fisheries and countries, and provide biological data to advance stock assessments.

- Develop a new generation of stock assessment models for stocks of HMS and coastal pelagic species in the Pacific Ocean and the state-of-the-art software to support them, using modern statistical optimization techniques, Bayesian methods, simulation, and object-oriented programming languages.

- Use pop-up satellite tags to identify forage and migration habitats of exploited species and protected resources in the central and western Pacific.

- Continue analysis of experimental longlines to understand HMS habitat requirements and options for bycatch reduction.

- Develop a spatial and temporal model to predict the catch of bigeye and yellowfin tuna in the Palmyra region.

- Assist local resource management agencies develop systems of marine protected areas (MPAs) appropriate for each island's marine ecosystems.

- Develop methods to assess the efficacy of various MPAs, ecosystem preserves, and other time-area closures in restoring fish stocks and increasing sustainable yields.

- Examine the role of ocean circulation on larval transport and recruitment of fish, corals, algae, and crustaceans with the goal of improved understanding of ecosystem dynamics and an ability to evaluate the effectiveness of no-take MPAs as refugia and replenishment areas.

I.B. Social and economic factors affecting abundance levels

- Expand sociological and economic research and incorporate results into the fishery management process (EIS, EA, NEPA).

- Develop behavioral models of economic incentives affecting the level and allocation of fishing effort in FMP fisheries.

- Evaluate the regulatory impacts of recent and potential time-area closures in the Hawaii domestic longline fishery using an updated economic programming model with the latest catch, effort, and price data.

- Enhance the empirical model and extend the application to include other fisheries (troll, handline, recreational fishing), which could enable an estimation of the change in the tradeoff value between small boats and longline fishery due to regulations.

- Conduct RIRs and RFAs for management actions being considered for all FMP fisheries.

- Evaluate alternative specifications of the economic programming models to test the impact of critical assumptions concerning longline fishing industry behavior.

I.C. Interdependence of fisheries or stocks of fish

- Develop integrative oceanic environmental indices to improve understanding of how environmental variability affects fish stocks.

- Extend analysis of factors affecting longline-turtle and longline-sea bird interactions to include more detailed oceanographic, tagging, and behavioral analysis.

- Evaluate the foraging ecology of the Hawaiian monk seal in terms of its use of fishery resources such as lobsters and bottomfish.

- Integrate central Pacific pelagic and insular ecosystem monitoring with stock assessments.

- Develop ecosystem models to describe ecosystem structure and dynamics for pelagic and insular ecosystems.

- Conduct fishery dynamics research on the rapidly growing American Samoa longline fishery.

- Continue work on developing better methods for estimating the incidental take of protected species.

- Expand the surveys of the deepwater coral community throughout the Pacific region, using archival instruments to characterize environment.

- Expand ECOPATH parameters beyond the FFS region.

- Continue work associated with identifying and understanding ecological links

between deep slope and shallow ecosystems with a focus on habitat aspects, particularly for fishery and protected species.

- Conduct studies on deep slope foraging habitat ecology of monk seals, black coral, and juvenile snappers in the main Hawaiian Islands.

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

- Continue studying the bank summit habitat ecology, and specifically study seasonality and growth of algal meadows using archival technology.

- Continue the research on deep slope habitat ecology, and specifically explore the use of acoustics technology to assess deep slope species.

- Develop effective tools to rapidly characterize and map benthic habitats of coral reef ecosystems around Hawaii, American Samoa, Guam, CNMI, and the Pacific remote island areas.

- Determine the spatial distributions, composition, extent and health of the benthic substrates.

- Determine and define the EFH and habitat area of particular concern (HAPC) for the coral reef areas.

- Associate identified habitats with distributions of the biological components of the ecosystem, including fish, invertebrates, and algae.

- Determine depth or habitat-based boundaries to support MPAs and the WPRFMC Coral Reef Ecosystem FMP.

- Provide high-resolution in-situ data to assist NOS in ground-truthing remote sensing-based mapping data of shallow water areas.

- Examine changes over time of the distribution and health of selected habitats, particularly corals, algae, and sand.

- Develop a multi-platform ocean observing system capable of monitoring the key physical and biological parameters likely to affect coral reef ecosystem health.

- Examine the role of ocean circulation on transport, distribution, and accumulation of marine debris with the goal of significantly improving debris removal efficiency and source identification.

- Develop GIS applications for mapping the NWHI lobster and bottomfish habitat, as well as identifying the interrelationship of precious (gold) coral and Hawaiian monk seal habitat.

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

Honolulu fish auction. Photo: D. Hawn, JIMAR.

- Evaluate the effects of climate change of interannual, decadal, and centennial scales on fisheries and fish habitat.

- Examine associations between the recruitment of juvenile insular species and climatic and oceanographic variables in the Hawaiian Archipelago.

- Investigate the linkage between the dynamics of oceanic features, including eddies, fronts, and boundary currents, and the dynamics of highly migratory fishes (tunas and billfishes) in the central and western Pacific.

- Develop and utilize a combination of remotely sensed observations of winds (scatterometers), temperature (AVHRR), sea surface height (altimeters), and ocean color (SeaWiFS and MODIS) to define regions of oceanic convergence and the likely accumulation of marine debris, and then develop methods to track and interdict marine debris at sea before it damages coral reef ecosystems.

- Identify derelict fishing gear and its probable sources based on gear type, material of construction, and construction methods used.

- Assess the amount of and evaluate the impacts of marine debris present on the coral reefs of the U.S. Pacific Islands.

- Remove marine debris from coral reefs and beaches to prevent further damage to the coral reef ecosystem and to mitigate entanglement hazards to the animals within the ecosystem.

- Continue to develop a campaign that promotes public awareness and education of marine debris affecting the U.S. Pacific Islands, focusing on educating the commercial fishing and maritime industries regarding the damage to coral reef ecosystems caused by marine debris and on efforts to minimize future damage by reducing or eliminating the sources.

II. Conservation Engineering Research

Recent Accomplishments:

A total of 194 experimental longline sets were conducted under a Scientific Research Permit (#1303) in the Pacific during March–July 2002 to explore measures to reduce longline fishery bycatch and mortality of sea turtles. Deep daytime fishing trials with stealth (camouflaged) fishing gear targeting swordfish were conducted to evaluate the economic viability of the modifications to typical swordfish fishing methods. Deployment of electronic hook timers and time depth recorders to document when and where turtle bycatch occurred and tests on the effectiveness of hook size and type (e.g., large circle hooks) on catch were also components of the experiment.

Approximately 90 at-sea observers were trained in attachment of pop-off satellite archival tags (PATs) in order to determine the impact of sea turtle longline interactions, such as survivorship and movement patterns of sea turtles post-release.

Research Priorities, FY 2004–2009:

- Undertake studies to determine the best methods to increase survival of protected, prohibited, or sensitive species caught by longline and troll vessels.

- Determine ways to reduce incidental capture of sea turtles in longline fishing gear through various sensory physiology experiments on sea turtles and targeted fish species (e.g., swordfish and tuna) in order to determine mechanisms used to attract (and eventually deter) both fish and turtles to bite baited hooks.

- Determine effective fishing gear modifications for reducing longline interactions with sea turtles, including at-sea experiments with the commercial longline fleet.

III. Research on the Fisheries

Recent Accomplishments:

The required social impact analysis (SIA) for the WPRFMC's proposed 50-mile area closure around Guam for bottomfish vessels greater than 50 feet in length was completed to fulfill the requirements for the WPRFMC's FMP amendment which would limit the bottomfishing activities of large vessels in the nearshore areas of Guam.

Recent analysis on the quantitative measurement of fishing capacity in the Western Pacific Region was presented to the 83rd Scientific and Statistical Committee (SSC) of the WPRFMC. The study covered capacity analysis for four major fisheries under the management of the WPRFMC—1) Northwestern Hawaiian Islands

(NWHI) lobster fishery, 2) NWHI bottomfish fishery, 3) Hawaii Pelagic longline fishery, and 4) American Samoa Pelagic longline fishery. Preliminary results indicate that excess capacity existed in some fisheries, especially in NWHI lobster fishery and NWHI bottomfish fishery. However, the study also suggested that additional analysis was needed; excess capacity can result from other factors such as changes in regulations, reduced stock abundance, or fluctuation of oceanic environment.

A GAM analysis on the catches of Pacific blue marlin has been completed. The correction of a large array of logbook data from the Hawaii-based longline fishery to generate a "research quality" database will now permit additional analyses such as computing standardized CPUE series for blue marlin from March 1994–June 2002 and comparing it to the official fishery statistics. The analysis shows that even with the well-organized procedures in place, relatively sophisticated analyses may still be necessary to improve data quality, even under virtually ideal circumstances for monitoring.

Interviews with more than 80 captains, owners, or crew of Hawaii-based longline vessels have been completed in support of ongoing baseline sociological studies. Interviews were unique, with a different set of questions depending on the interviewee's interests, concerns, knowledge, and role in the industry and provided information describing the background of longline participants, including how they came to be involved in the fishery, and their perceptions of the fishing lifestyle, fisheries management and its impacts, and the longline fishing community and industry.

Research Priorities, FY 2004–2009:

III.A. Social and economic research

- Develop automated analytical templates integrated with current fishery performance, cost, and price information for completing RFAs in an efficient and timely basis. Augment these templates to include the basic demographic information required to initiate preliminary SIAs.

- Continue to research and update intra-industry linkages and develop input-output relationships to describe and model the employment, income, and economic activity impacts of management actions being considered for each of the FMP fisheries and fishing communities.

- Develop methods to compare and assess the various management options including MPAs, ecosystem preserves, and other time-area closures in restoring fish stocks and increasing sustainable yields.

- Develop methods and models to assess the effects of various management options on the recreational and subsistence fisheries in the island areas.

- Research the social and economic ramifications of the various management options on the recreational and subsistence fisheries in the island areas.

- Study small-boat, charter-boat, and tournament anglers to elicit explicit non-market economic values for blue marlin using standard contingent valuation techniques.

- Resurvey the Hawaii-based domestic longline fleet to provide revised baseline data for conducting regulatory impact analyses on forthcoming regulations.

- Develop a long-term monitoring program to provide baseline economic and social data for use in making fisheries management decisions.

- Develop an Economic Data Collection program that will cover Fishing Club Members and Tournament Participants in Hawaii.

- Develop profiles of fishing ports and communities in Hawaii, Guam, American Samoa, and CNMI. On July 3, 2003, NMFS approved a proposed definition of MSFCMA fishing communities in Hawaii that defined each of the major inhabited islands as a fishing community for the purposes of MSFCMA. This follows earlier approval of the definition of Guam, American Samoa, and CNMI each as a fishing community. This research examines patterns of engagement in and dependency on various fisheries within these broadly-defined fishing communities.

- Examine the economic values and policy tradeoffs associated with conservation and protection of threatened and endangered sea turtles in the Pacific.

IV. Information Management Research

Recent Accomplishments:

The WPacFIN American Samoa integrated data management system has implemented a longline logbook processing system which now includes field sampling and size frequency collection data. The non-confidential data summaries are available on-line through the WPacFIN website.

WPacFIN completed the PIFSC contribution to the annual report "Fisheries of the United States." Data summaries from Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Marianas were produced in a newly revised format this year.

The PIFSC ESDIM data rescue project created to archive the vast amount of hard copy data holdings was recently completed. The project has "saved" previously archived data on electronic media for use in retrospective and historical studies. The data archived spanned from the late 1940's to the present and resulted in approximately 33 gigabytes of archived data. The project advances the PIFSC's commitment to OMB's Paperwork Reduction Act requirements.

In partnership with collaborating agencies, the NOAA Coral Reef Information System (CoRIS) was developed.

JIMAR and PIFSC staff in the ITS group developed a new enterprise data management system for capturing, editing, archiving, and delivering complex data from the Hawaii longline observer program operated by the PIRO. The work was done cooperatively with PIRO observer program staff using Oracle database development tools. This project, supported partially by FIS funds, is part of PIFSC efforts to develop a comprehensive enterprise database management system supporting marine resource data needs of NMFS and its constituents in the Pacific Islands Region. Fishery database development efforts include entering and validating data from several primary fisheries and incorporating them into Oracle database tables where they are accessible by research and monitoring staff; over time, more data sets will be added. Important advances are being made by ITS staff in the development of enterprise database tools. These include tools for web-based management and documentation of changes (edits) to Oracle database entries accessible by all data users and a general data portal technology called InPort, with the potential to create and manage metadata relating to many functions of PIFSC and PIRO, both scientific and administrative.

In addition, PIFSC and JIMAR data management staff are partnering with colleagues at PIRO, SWFSC, and SWR to coordinate the management of U.S. data for highly migratory species (HMS) in the Pacific. The latter project involves jointly developing solutions to address HMS data issues in the Pacific, including data collection and processing standards, data catalogs and metadata, data submissions, data access, and other issues.

Many of the improvements in enterprise data management systems, such as tools for metadata, quality control, management of database changes, and documentation help to satisfy NMFS requirements under the Data Quality Act.

Research Priorities, FY 2004–2009:

- Implement a comprehensive Oracle-based integrated system for storing and distributing, via the Internet, appropriate PIFSC data holdings, including fisheries dependent, research cruise, remote sensing, laboratory, and video data.

- Develop GIS technology for mapping and spatial analysis of fisheries, oceanographic, and habitat information

- Advance approaches of data fusion to combine fisheries data and assessment model outputs with environmental data from ship, satellite, and physical models.

- Implement ORACLE-based integrated system for storing and distributing via the internet all of the Honolulu Laboratory data holdings, including fisheries dependent, research cruise, remote sensing, laboratory, video data, etc.

- Automate quarterly and annual compilation of fisheries statistics and annual reports on FMP fisheries.

- Maintain and improve the web-based access to non-confidential data. Investigate new avenues for public access to data.

- Research, develop and implement electronic data reporting programs for all areas and technology for fisheries dependent information, i.e., electronic logbooks, seafood dealer reporting systems, etc.

- Research and develop alternate data reporting instruments and ways of archiving data to fulfill the Paperwork Reduction Act requirements.

- Develop automated systems for integrating data sets with common fields (e.g., longline logbook and observer reports, NOAA research vessel cruise data, and satellite oceanographic remote sensing).

- Continue to improve data security and data quality practices.

- Enhance and improve the fisheries monitoring input and output programs of the island areas.

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APPENDIX A

Crosswalk Table: NFSP and NSPFR

The following table presents the outline of the NOAA Fisheries Strategic Plan goals and elements in the left column and corresponding elements of the MSFCMA-required NMFS Strategic Plan for Fisheries Research in the right column.

NOAA Fisheries Strategic Plan Outline	NMFS Strategic Plan for Fisheries Research
NOAA MISSION GOAL 1: Protect, Restore, Manage—Strategies and Elements	
Monitor and Observe	
Fisheries Information System	IV. Information management research
Observers	I.A. Biological research concerning stock abundance
Observing Platforms /Advanced Technology	I.A. Biological research concerning stock abundance
Habitat Assessment, Restoration Monitoring	I.D. Identifying, restoring, and mapping of essential fish habitat
Social Science	I.B. Social and economic factors affecting abundance levels
	III.A. Social and economic research
Industry Partnerships	I.A. Biological research concerning stock abundance
Understand and Describe	I.E. Impact of anthropogenic factors and environmental changes on fish populations
Habitat	
Marine Noise	
Assess and Predict	
Stock Assessment Improvement Plans	I.A. Biological research concerning stock abundance
Ecosystem Modeling	I.C. Interdependence of fisheries or stocks of fish
Engage, Advise, and Inform	Indirect Support
Manage	
Regulatory Streamlining	Not Fisheries Research
Bycatch Reduction	Conservation engineering research
Capacity Reduction	Not Fisheries Research
Aquaculture	III.C. Marine aquaculture
Modernization of Enforcement	Not Fisheries Research
NOAA MISSION GOAL 2. Understand Climate Variability And Change	I.C. Interdependence of fisheries or stocks of fish
NOAA MISSION GOAL 3. Serve Society's Needs For Weather Information	Not Fisheries Research
NOAA MISSION GOAL 4. Support The Nation's Commerce/ Transportation	Not Fisheries Research
NOAA'S CROSS-CUT PRIORITIES:	
1) Integrated Global Environ. Observ. and Data Mgmt. Sys.	Indirect Support
2) Environmental Literacy, Outreach, and Education	Indirect Support
3) Sound, State-of-the-Art Research	Indirect Support
4) International Cooperation and Collaboration	Indirect Support
5) Homeland Security	III.B. Seafood safety research
6) Organizational Excellence	Indirect Support

APPENDIX B

Response to Comments on Public Draft of the NSPFR

In December of 2003, NMFS published a Notice of Availability in the Federal Register announcing the availability of the draft Strategic Plan for Fisheries Research. Comments were received from eight organizations and individuals, representing a range of interests. The comments were helpful in revising the plan and preparing the final document. This appendix summarizes the comments and addresses each major comment. Some commenters also identified inconsistencies in the draft plan and suggested editorial or textual changes. These specific comments are not addressed here. However, the final plan document incorporated these suggestions as much as possible.

Comment: The Plan does not have protected species research specifically broken out and is integrated under the main research headings. Research activities and priorities aimed at supporting protected species management should be expanded.

Response: Section 404 of the MSFCMA delineates four specific areas of research: 1) research to support fishery conservation and management; 2) conservation engineering research; 3) research on the fisheries; and 4) information management research. The scope of the present document is solely research to support the Act and it addresses protected resources only as they relate to sustainable fisheries. NMFS is in the process of developing a "Protected Resources Stock Assessment Improvement Plan" which will directly address research requirements for the conservation of protected resources.

Comment: The Plan should include research efforts regarding the use of artificial structures to enhance fisheries.

Response: NMFS agrees and has revised the document to reflect research evaluating the potential of artificial reef / habitat.

Comment: For the SEFSC overview, NMFS should specifically establish bycatch / regulatory discards evaluations as a high priority

Response: NMFS agrees that bycatch / regulatory discard evaluations should be included as a priority applicable to all programs in the entire southeast within the context of an ecosystem approach. NMFS has modified this section accordingly.

Comment: Established collaborative linkages between the SWFSC and the PIFSC for highly migratory species and research to support international fishery management are not well specified in this Plan.

Response: The SWFSC and PIFSC share interests in highly migratory species research driven by differing constituent groups and different Fishery Management Councils. It is correct that there is overlap in the broad interests of the two Science Centers and the text has been modified to convey this. However, actual research projects, data management, stock assessments, etc., are conducted in a collaborative manner designed to minimize redundancy, best utilize resources, and adequately represent NMFS in various fora. Specifying such actions is too detailed for this Plan and are the responsibility of the respective Science Center directors to develop and adjust as situations demand.

Comment: For the PIFSC overview, NMFS should be more explicit about the research undertaken in the constituent islands of the Western Pacific region.

Response: NMFS agrees and has revised the document to reference constituent Western Pacific islands where applicable. These islands are also included where research is defined for the Western and Central Pacific.

APPENDIX C

Abbreviations and Acronyms

ABC	acceptable biological catch
ABL	Auke Bay Laboratory
ACCSP	Atlantic Coastal Cooperative Statistics Program
ADCP	acoustic Doppler current profiler
ADFG	Alaska Department of Fish and Game
AFA	American Fisheries Act
AFSC	Alaska Fisheries Science Center
AGU	American Geophysical Union
AI	Aleutian Islands
AKFIN	Alaska Fisheries Information Network
AOP	Annual Operating
APIS	Antarctic pack ice seal
ASMFC	Atlantic States Marine Fisheries Commission
ASRG	Alaska Scientific Review Group
AVHRR	advanced very high resolution radiometer
BASIS	Bering Aleutian Salmon International Survey
BRDs	bycatch reduction devices
BSAI	Bering Sea and Aleutian Islands
BSMDBS	Biological Sample Monitoring Data Base System
BUSL	buoy-utility stern loading
CAFF	Conservation of Arctic Flora and Fauna
CAGEAN	catch-age analysis
CalCOFI	California Cooperative Fisheries Investigations
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CDQ	community development quota
CFDBS	Commercial Fisheries Data Base System
CFMC	Caribbean Fishery Management Council
CMER	Cooperative Marine Education and Research
CMSS	Center for Marine Social Sciences
CoML	Census of Marine Life
CoRIS	Coral Reef Information System
CPS	coastal pelagic species
CPUE	catch-per-unit-of-effort
CRED	Coral Reef Ecosystem Division
CRI	Cumulative Risk Initiative
CZCS	coastal zone color scanner
DMS	Data Management Systems
DNA	deoxyribonucleic acid
DOC	Department of Commerce
DODS	Department of Defense standard

DON	dissolved organic nitrogen
DPSEIS	Draft Programmatic Supplemental Environmental Impact Statement
EA	Environmental Assessment
EbM	ecosystem-based management
EBS	Eastern Bering Sea
EEZ	Exclusive Economic Zone
EFCL	electronic fish catch logbook
EFH	essential fish habitat
EIS	Environmental Impact Statement
EO	Executive Order
EOD	Ecosystems and Oceanography Division
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESDIM	Environmental Services and Data Information Management
ESU	evolutionarily significant unit
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FBSAD	Fish Biology and Stock Assessment Division
FHDBS	Food Habits Data Base System
FIN	Fisheries Information Network
FMC	fishery management council
FMP	fishery management plan
FMPD	Fishery Management and Performance Division
FOCI	Fisheries Oceanography Coordinated Investigations
FSCS	Fisheries Scientific Computer System
FTE	full-time equivalent
GAM	generalized additive model
GARM	Ground Fish Review Assessment Meeting
GB	Georges Bank
GIS	geographic information system
GLOBEC	Global Ocean Ecosystems Dynamics
GMFMC	Gulf of Mexico Fishery Management Council
GOA	Gulf of Alaska
GOM	Gulf of Maine
GSMFC	Gulf States Marine Fisheries Commission
GulfFIN	Gulf of Mexico Fisheries Information Network
HAB	harmful algal bloom
HAPC	habitat areas of particular concern
HMS	highly migratory species
HMAP	History of Marine Animal Populations
HURL	Hawaii Undersea Research Laboratory
IATTC	Inter-American Tropical Tuna Commission
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Seas
IFQ	Individual Fishing Quota
IFREMER	Institute Francais de Recherche pour l'Exploitation de la Mer (French Research Institute for Exploitation of the Sea)

IOCARIBE	International Oceanographic Commission for the Caribbean
ISC	Interim Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean
ITQ	individual transferable quota
IWC	International Whaling Commission
JIMAR	Joint Institute for Marine and Atmospheric Research
LIDAR	light detection and ranging
LIS	Long Island Sound
LME	large marine ecosystem
LMR	living marine resource
MAB	Mid-Atlantic Bight
MAFMC	Mid-Atlantic Fishery Management Council
MBL	Marine Biological Laboratory
MHLC	Multilateral High-Level Conference on the Conservation and Managemen of the Highly Migraory Fish Stocks in the Western and Central Pacific Ocean
MMPA	Marine Mammal Protection Act
MMPM	multilevel multiobjective programming model
MODIS	moderate resolution imaging spectroradiometer
MSDBS	Marine Mammal Stranding Data Base System
MPA	marine protected area
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	maximum sustainable yield
NATURES	Natural Rearing Enhancement System
NEFMC	New England Fishery Management Council
NEFSC	Northeast Fisheries Science Center
NEPA	National Environmental Policy Act
NER	Northeast Region
NERO	Northeast Regional Office
NFSP	NOAA Fisheries Strategic Plan
NGO	nongovernment organization
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NOAA	National Oceanic and Atmospheric Administration
NODC	National Oceanographic Data Center
NOS	National Ocean Service
NPAFC	North Pacific Anadromous Fish Commission
NPALB	North Pacific Albacore Workshop
NPFMC	North Pacific Fisheries Management Council
NRC	National Research Council
NSL	National Systematics Laboratory
NSPFR	NMFS Strategic Plan for Fisheries Research
NURP	National Undersea Research Program
NWFSC	Northwest Fisheries Science Center
NWHI	Northwestern Hawaiian Islands
NWIC	Northwest Indian College
OBDBS	Observer Data Base System
OCC	ocean carrying capacity
OMB	Office of Management and Budget

OMI	Operations Management and Information
OY	optimum yield
PacFIN	Pacific Coast Fisheries Information Network
Pacific RecFIN	Pacific Recreational Fisheries Information Network
PaCOS	Pacific Coastal Observing System
PAT	pop-up archival tag
PCR	polymerase chain reaction
PFEL	Pacific Fisheries Environmental Laboratory
PFMC	Pacific Fishery Management Council
PICES	North Pacific Marine Science Organization
PIFSC	Pacific Islands Fisheries Science Center
PIT	passive integrated transponder
PMEL	Pacific Marine Environmental Laboratory
PSMFC	Pacific States Marine Fisheries Commission
PPT	Project, Planning, and Tracking
RACE	Resource Assessment and Conservation Engineering Division, AFSC
RDBMS	Relational Data Base Management System
REA	rapid ecological assessment
RecFIN	Recreational Fisheries Information Network
REFM	Resource Ecology and Fisheries Management Division, AFSC
RFA	regulatory flexibility analysis
RIR	regulatory impact review
ROV	remotely operated vehicle
RPAC	Research Planning and Coordination
SAFE	stock analysis and fishery evaluation
SAFMC	South Atlantic Fishery Management Council
SAIP	Stock Assessment Improvement Plan
SARC	Stock Assessment Review Committee
SAW	stock assessment workshop
SCTB	Standing Committee on Tuna and Billfish
SeaWiFS	sea-viewing wide field-of-view sensor
SEDAR	Southeast Data Assessment and Review
SEFDBS	Scallop Experimental Fisheries Data Base System
SEFSC	Southeast Fisheries Science Center
SEM	scanning electron microscopy
SFA	Sustainable Fisheries Act of 1996
SIA	social impact assessment
SMAST	School of Marine Science and Technology
SNE	Southern New England
SPO	NMFS Scientific Publications Office, Seattle, WA
SPTT	South Pacific Tuna Treaty
SSC	Scientific and Statistical Committee
SSDBS	Sea Sampling Data Base System
SST	sea surface temperature
SWFSC	Southwest Fisheries Science Center
TED	turtle excluder device
TRT	technical recovery team
UN	United Nations

UNCLOS	United Nations Convention on the Law of the Sea
URI	University of Rhode Island
USDI	United States Department of the Interior
VADM	Vice Admiral
WHOI	Woods Hole Oceanographic Institution
WPacFIN	Western Pacific Fisheries Information Network
WPRFMC	Western Pacific Region Fishery Management Council

APPENDIX D

Glossary

Acceptable biological catch (ABC): The ABC is a scientific calculation of the sustainable harvest level of a fishery as determined by Federal fisheries biologists.

Acoustic Doppler current profiler (ADCP): An acoustic sensor that measures the Doppler shift of acoustic scatterers in the water column and estimates the magnitude and direction of 3-D motions of the "water" versus depth, using the assumption that the scatterers are passive tracers of the water mass. Fisheries scientists have applied this sensor to look for biological constituents (i.e., eggs and larvae) in the water column.

Adaptive management: A combination of stock assessments with prior knowledge of the fishery coupled with quantitative modeling and empirical management experimentation.

Anadromous: Fish stocks that migrate from saltwater to fresh water to spawn.

Anthropogenic: Human caused; usually used in reference to risks created to fish stocks by human activities.

Atlantic Coastal Cooperative Statistics Program (ACCSP): A cooperative state-Federal marine and coastal fisheries data collection program. The goal of the program is to cooperatively collect, manage, and disseminate fishery statistical data and information for the conservation and management of fishery resources of the Atlantic coast and to support the development and operation of a national data collection and data management program.

Benthic: Refers to organisms which live at or near the bottom (see Demersal).

Biomass: The total weight of organisms in a defined group, such as a fish stock or year class.

Broodstock: Adult fish used to propagate the subsequent generation of hatchery fish.

Bycatch: The Magnuson-Stevens Fishery Conservation and Management Act defines bycatch as "fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards... [But not] fish released alive under a recreational catch and release fishery management program."

Bycatch reduction device (BRD): Any of a number of implements that have been certified to reduce the likelihood of capturing nontarget species.

Catch per unit effort (CPUE): The amount of fish that is caught by a given amount of fishing effort. Typically, effort is a combination of gear type, gear size, and length of time the gear is used.

Charter fishing: Fishing from a vessel carrying a passenger(s) for hire who is engaged in recreational fishing.

Commercial fishing: Fishing in which the fish harvested, either in whole or in part, are intended to enter commerce or enter commerce through sale, barter, or trade.

Conservation engineering: The practice of determining the modification in gear design that will meet conservation objectives, such as decreasing bycatch and bycatch mortality by increasing the selectivity of gear and increasing the survival of fish and other living marine resources that fishing gear encounter inadvertently.

Continental shelf: Submerged margin of continent from low-tide line to a point (generally between the 50 and 100 fathom isobaths) at which there is a marked increase of slope (i.e., the continental slope) to greater depth.

Delisting criteria: Determination as to what indicators need to exist before stocks can be taken off the list of endangered species. Typically, delisting criteria are elaborated by policy decisions regarding various recovery activities, such as reforming hatchery practices, reducing harvest, eliminating impacts of dams or restoring habitat.

Demersal: Fish and animals that live near the bottom of an ocean.

Endangered species: A species is considered "endangered" if it is in danger of extinction throughout a significant portion of its range; it is considered "threatened" if it is likely to become an endangered species.

Endangered Species Act (ESA): The Federal law, enacted by Congress in 1973, to provide protection for, and promote recovery of, animal and plant species considered as threatened or endangered because of natural or anthropogenic conditions.

Essential fish habitat (EFH): The Magnuson-Stevens Fishery Conservation and Management Act defines essential fish habitat as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

Evolutionarily significant unit (ESU): An ESU represents a distinct population segment under the that 1) is substantially reproductively isolated from nonspecific populations and 2) represents an important component of the evolutionary legacy of the species.

Exclusive Economic Zone (EEZ): The zone contiguous to the territorial sea of the United States, the inner boundary of which is a line coterminous with the seaward boundary of each of the coastal states and the outer boundary of which is a line drawn in such a manner that each point on it is 200 nautical miles from the baseline from which the territorial sea is measured. This zone was established by Proclamation Numbered 5030, dated March 10, 1983.

Exploitation rate: The probability that a given fish will die during the year because of fishing.

Ex-vessel value: The amount paid to vessel's owner or operator for its catch, excluding any value added by at-sea processing.

Fishery: a) One or more stocks of fish which can be treated as a unit for purposes of conservation and management and which are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics; and b) any fishing for such stocks.

Fishery dependent data: Data collected on a fish or a fishery from sport fishers, commercial fishers, and seafood dealers.

Fishery independent data: Data collected on fish by scientists who catch the fish themselves, rather than depending on fishermen or seafood dealers.

Fishery management council (FMC): One of eight regional groups established under Section 302 of the Magnuson-Stevens Fishery Conservation and Management Act to prepare and oversee fishery management plans for fisheries conducted principally within the Exclusive Economic Zone.

Fishery management plan (FMP): A plan developed by a regional fishery management council, or the Secretary of Commerce under certain circumstances, to manage a fishery resource in the U.S. EEZ pursuant to the Magnuson-Stevens Fishery Conservation and Management Act. Includes data, analyses, and management measures for a fishery.

Gillnet: A flat net suspended vertically in the water used to capture fish which entangle themselves in the net, usually by the forward part of the body near the gills.

Groundfish: A species of fish, usually finfish, that live on or near the sea bottom part of the time.

Juvenile: A young fish, usually resembling an adult in appearance, but which has not yet become sexually mature.

Krill: Small abundant crustaceans that form an important part of the food chain in Antarctic waters.

Landings: The number or poundage of fish unloaded at a dock by commercial fishers or brought to shore by recreational fishers for personal use. Landings are reported at the points at which fish are brought to shore.

Marine Mammal Protection Act (MMPA): The MMPA is a statue which was enacted in 1972 to protect marine mammals and their habitat. These species include whales, dolphins, seals, seal lions, walruses, and others.

Mark-recapture: The tagging and releasing of fish to be recaptured later in their life cycles. These studies are used to study fish movement, migration, mortality, and growth, and to estimate population size.

Maximum Sustainable Yield (MSY): A management goal specifying the largest long-term average catch or yield (in terms of weight of fish) that can be taken, continuously (sustained) from a stock or stock complex under prevailing ecological and environmental conditions, without reducing the size of the population.

Metapopulation: A group of partially isolated populations (or subpopulations) belonging to the same biological species (or subspecies) and connected by migratory pathways. These partially isolated populations or subpopulations can exchange individuals, which are potentially able to recolonize sites within the metapopulation from which the species or subspecies recently became extinct.

MULTIFAN CL: A computer program that implements a statistical, lengh-based, age-structured model for use in fisheries stock assessment.

Pinger: High-frequency acoustic devices that may keep marine mammals from entering and becoming entangled in fishing nets.

PIT-tag: The passive integrated transponder (PIT) tag is an electronic tag 10 mm long by 2.1 mm in diameter that can be coded with one of 35 billion codes. The tag can be automatically detected and decoded in situ and eliminates the need to sacrifice, anesthetize, handle, or restrain fish during data retrieval. The tag has been developed as a research and management tool for monitoring the movement of juvenile and adult fish species.

Plankton: Plants (phytoplankton) and animals (zooplankton) which float in the upper portion of the water column and provide the basic constituents of the oceanic food web. Most planktonic organisms are microscopic in size. Eggs and larvae of many fisheries species are also components of the plankton community.

Population: A group of interbreeding organisms generally inhabiting a given geographic area.

Opportunity cost: An amount a fisher could earn for his/her time and investment in another business or occupation.

Optimum yield (OY): a) The amount of fish which will provide the greatest overall benefit to the Nation, particularly with respect to food production and

recreational opportunities, and taking into account the protection of marine ecosystems; b) is prescribed as such on the basis of the maximum sustainable yield from the fishery, as reduced by any relevant economic, social, or ecological factor; and c) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the maximum sustainable yield in such fishery.

Quota: The maximum amount of fish that can be legally landed in a time period. It can apply to the entire fishery, an individual fisher's share under an individual fishing quota (IFQ) system, or refer to the size of fish.

Recreational Fisheries Information Network (RecFIN): A cooperative state-Federal effort among marine fisheries agencies to improve collection and management of marine recreational fisheries statistical information.

Recruitment: A measure of the weight or number of fish which enter a defined portion of stock, such as the fishable stock or the spawning stock.

Regulatory impact review (RIR): The part of a federal fishery management plan that describes impacts resulting from the plan.

Relative abundance: An index of fish population abundance used to compare fish populations from year to year. This does not measure the actual numbers of fish, but shows changes in the population over time.

Saltonstall-Kennedy Grant Program: A competitive program that provides funds through grants or cooperative agreements for research and development projects to benefit the U.S. fishing industry. The Saltonstall-Kennedy Act, as amended [15 U.S.C. 713 (c) (3)], is the program's statutory authority.

Stakeholder: One who is expected to receive economic or social benefits from the conservation and management of living marine resources.

Stock: A more-or-less discrete and identifiable unit of fish or other exploited species, often referring to a management unit.

Stock assessment: The biological assessment of the status of the resources. This analysis provides the official estimates of stock size, spawning stock size, fishing mortalities, recruitment, and other parameters.

Stock assessment workshop (SAW): A cooperative stock assessment activity in which scientists from various agencies evaluate the status of fish stocks.

Subsistence fishing: Fishing for personal consumption or traditional/ceremonial purposes.

Technical Recovery Team (TRT): A panel of scientists set up to define "delisting criteria" in specific geographic domains for endangered salmon and steelhead species on the west coast.

Trophic web: The network that represents the predator/prey interactions of an ecosystem.

Turtle excluder device (TED): An implement that has been certified to reduce the likelihood of capturing turtles.

Yield-per-recruit: The average weight of fish ultimately harvested for each fish that enters the fishery.

Virtual population analysis: A mathematical analysis in which catch data are used to estimate absolute abundances of age-classes in a stock and the fishing mortality that has been sustained by those age-classes.