CENTER CONSPECTUS

NORTHEAST FISHERIES CENTER
NATIONAL MARINE FISHERIES SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
UNITED STATES DEPARTMENT OF COMMERCE

WOODS HOLE, MASSACHUSETTS
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CONTENTS

INTRODUCTION

"Our fisheries are one of the Nation's--indeed the world's--greatest resources and will become increasingly important as a source of food for man in the decade ahead. We cannot permit the depletion of our fish stocks and the destruction of fish habitats to continue. We must learn to manage this resource so that we may use it to the optimum now and so that future generations may be able to use it and draw even greater yields from it."

National Plan for Marine Fisheries (1976)

The National Marine Fisheries Service's (NMFS) charter mandates it to discover, describe, develop, and conserve the renewable natural resources of the marine ecosphere, particularly as those resources affect the American society and economy. As the research arm of NMFS in the Northeast and Middle Atlantic States, the Northeast Fisheries Center (NEFC) studies these resources in the Northwest and Middle Atlantic and advises on their development, utilization, conservation, and management.

To fulfill its conservation and management roles, the NEFC collects and analyzes data useful in the preparation of management plans to achieve optimum yields from the fisheries resources. The Fishery Conservation and Management Act (FCMA) of 1976 defines optimum yield as the amount of fish which provides the greatest overall benefit to the nation, particularly for food and recreation, and which is the maximum sustainable yield as modified by relevant economic, social, and/or ecological factors. Accordingly, the NEFC assesses the maximum sustainable yield of all fishable stocks and of the total fishable biomass. These assessments take into consideration natural and man-made environmental conditions that affect those stocks and the biomass.

To fulfill its development and utilization roles, the NEFC advises other governmental research agencies, private industry, and the general public on how to produce desirable and safe fishery products. Appropriately, the NEFC aids fisheries development through the study of utilization technology, investigates aquacultural processes, and evaluates economic factors.

The FCMA, the 1976 National Plan for Marine Fisheries (NPMF), and the 1977 National Oceanic and Atmospheric Administration's (NOAA) Aquaculture Plan (NAP) focus these functions and mandate. The FCMA creates a zone from 3 to 200 miles offshore in which the United States has authority over fisheries

resources except for highly migratory species such as the Atlantic bluefin tuna. A set of standards within the FCMA calls for: (1) all conservation and management measures in the zone to prevent overfishing, achieve optimum yields on a continuing basis, use the best available scientific information, promote efficient use of fisheries resources, and minimize costs; (2) the management of each fish stock as a unit throughout its range; and (3) the fair, equitable, and conservation-promoting allocation or assignment of fishing privileges when and where such actions are necessary. These standards are implemented in management plans by Regional Fishery Management Councils. The two Councils in the Northeast and Middle Atlantic States, the New England Council (Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut) and the Mid-Atlantic Council (New York, New Jersey, Pennsylvania, Maryland, Delaware, and Virginia), respectively, are primarily composed of members nominated by the governors of each state in the region and appointed by the Secretary of Commerce. Since the Secretary of Commerce and the Regional Fishery Management Councils are the principal implementers of the FCMA, the information gathered by, and the advice of the NEFC to the Secretary and the Councils are important elements in the FCMA's realization in the Northwest and Middle Atlantic.

The NPMF advocates: (1) the restoration, maintenance, enhancement, and rational utilization of important marine fisheries resources; (2) the development and maintenance of a healthy commercial fishery; (3) the strengthening of the contribution of marine fisheries resources to recreational and other social needs; and (4) the assurance of adequate supplies of wholesome seafood products for consumers. The NEFC designs its research program specifically to accomplish these goals. The program concentrates on marine fisheries resources and their habitats; on commercial, recreational, and other social aspects of these resources; and on aquaculture and the handling of fisheries products.

The basis for the NAP is that the world now harvests close to the maximum yield of conventional fisheries resources, and within 10 years the growth rate of the human population will create a worldwide shortage of seafoods. Aquaculture is one solution to the problem, but the United States' aquacultural production is 70 percent below the worldwide average in terms of what proportion of seafood consumed has been artificially produced. NOAA will attempt to increase, through public hatcheries or private industry, the production of selected species. NOAA will do this by: (1) performing research for biological and technical information necessary to successful aquaculture; (2) determining and dealing with social, economic, institutional, and legal barriers to aquaculture; and (3) ensuring that aquacultural species are considered in coastal zone management plans and actions. The NEFC's aquacultural research is restricted to (1) above.

In addition, the growing concern for the effects of marine pollution, not only on the yield of fisheries resources, but also on the health of human populations, calls for answers soon on what are the effects of such contamination. Current studies of specific pollutants at specific sites cannot cover the larger areas and longer times that these pollutants affect. The

NEFC will coordinate its studies and the studies of other groups to determine the ecosystem-wide effects of marine pollution and to distinguish between those effects due to such contaminants and those due to natural factors. The NEFC will continue its long-term studies into fundamental ecological processes and will also begin short-term monitoring studies to learn what ecological events are happening and why they are occurring.

CENTER ORGANIZATION

Figure 1 shows the structural organization of the NEFC. All elements report to the Center Director. He administers NMFS's research programs, laboratories, and personnel in the Northeast and Middle Atlantic States. He is also the principal scientific advisor to the Northeast Regional Director and the Director of NMFS on the fisheries resources of the Northwest and Middle Atlantic, and the primary coordinator of NEFC activities with private organizations and other domestic and foreign governmental agencies.

The NEFC Board of Directors is the official forum for the planning, development, and coordination of the research program. Board members include the Center Director, Center Operations Officer, Center Planning Officer, Laboratory Directors, Division Managers, Regional Director, Regional Personnel Officer, Special Scientific Assistants, and Extended Jurisdiction Liaison Assistants.

The Center Operations Officer is the principal advisor to the Center Director on the administration and operation of the NEFC's laboratories. He recommends administrative policies, coordinates administrative management, and supervises budget implementation and technical support activities for the Center. Reporting to the Center Operations Officer are five support units: Administrative Budgeting, Automatic Data Processing, Vessel Operations, Technical Information, and Aquarium. The Administrative Budgeting Unit assures compliance of NEFC activities with official budgetary policy and monitors the allocation and flow of funds. The Automatic Data Processing Unit provides data-system analysis, programming, data conversion, data-base establishment and maintenance, and data reports and analyses. The Vessel Operations Unit programs the activities of research vessels, including those of foreign governments, participating in the NEFC research program. The Technical Information Unit assists in the production, dissemination, and accounting of scientific, technical, and public information. The Aquarium Unit informs the public on the marine environment and its organisms, and on the functions and activities of NOAA, NMFS, and the NEFC in the marine field. The aquarium also provides an experimental facility for studies on the biology and ecology of marine species.

The Center Planning Officer coordinates the development of program priorities, planning documents, future budgets, and program reviews. He engages in special staff assignments and oversight activities at the request of the Center Director, and coordinates the activities of the NEFC Board of Directors.

The Special Scientific Assistants advise the Center Director on special research problems. They conduct their own research, advise on the publication of the findings of other NEFC studies, represent the Center Director at various scientific meetings, coordinate the communications between the International Council for the Exploration of the Sea and American representation, and undertake special projects at the request of the Center Director.

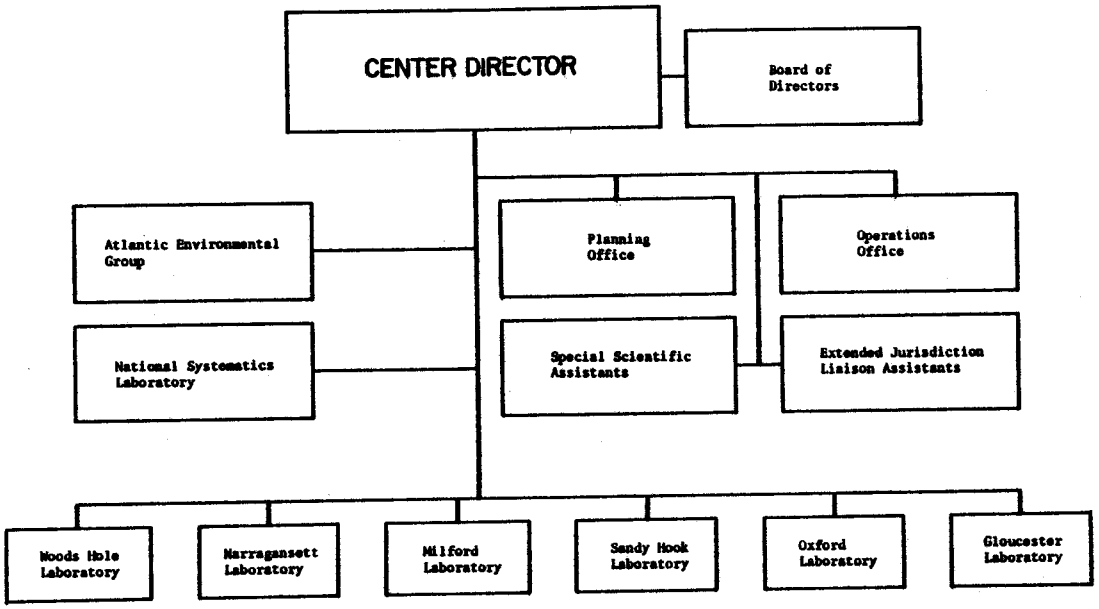

FIGURE 1

ORGANIZATION

OF THE NORTHEAST FISHERIES CENTER

The Extended Jurisdiction Liaison Assistants inform the New England and Mid-Atlantic Councils on the one hand, and the NEFC on the other hand, of the activities and recommendations of the other(s). They administer special internal and contract studies on the capabilities and socioeconomics of the commercial fishing industry, and on the status of the recreational fisheries.

The National Systematics Laboratory, or NSL (Washington, D.C.), and the Atlantic Environmental Group, or AEG (Narragansett, Rhode Island), are administered by the NEFC. However, the jurisdiction of the research programs of the NSL and AEG extends beyond the Northeast and Middle Atlantic States. The NSL has a national jurisdiction and the AEG has an Atlantic Ocean-Gulf of Mexico jurisdiction. Each NEFC laboratory (Woods Hole, Narragansett, Gloucester, Sandy Hook, Milford, and Oxford) has a Director who assists the Center Director in the planning, development, and coordination of the laboratory's research activities, and administers the laboratory's operations.

RESEARCH PROGRAM

MISSION

The former Northeast Fisheries Center, Middle Atlantic Coastal Fisheries Center, Northeast Utilization Research Center, National Systematics Laboratory, and Atlantic Environmental Group comprise the current NEFC. The new Center's research program provides scientific expertise needed for fisheries management, environmental management, and fisheries production and utilization.

Research for fisheries management focuses on the size, composition, structure, and changes in these parameters, of the fisheries resources of the Northwest and Middle Atlantic. These data, when combined with data on the effects of natural and man-made environmental factors on those resources, permit the prediction of the surplus production of those resources. Relevant social, economic, and/or ecological factors are incorporated into these estimates. These data, predictions, and calculations, provide the Regional Councils with information necessary to produce fishery management plans for the fisheries resources of the Northwest and Middle Atlantic. If, in the opinion of the Secretary of Commerce, the Councils fail to produce a plan for any fishery in need of conservation or management, or if the Councils produce a plan inconsistent with the FCMA, then the Secretary solicits a draft of such a plan from the NEFC.

Research for environmental management provides information on the kinds and degrees of natural and man-made environmental factors in the Northwest and Middle Atlantic. This information comes from conducting baseline studies of the occurrence of marine contaminants and their effects on commercially, recreationally, and/or ecologically important species, and from monitoring changes in such physical and chemical factors as water movements, temperatures, and dissolved oxygen concentrations. These baseline studies and monitoring efforts often include dump sites for sewage sludge, dredge spoils, industrial chemicals, and power plant thermal effluents, in order to determine the effects of such specific sites and types of contamination on the marine environment and its fisheries resources.

Research into fisheries resource production and utilization serves industry and the public by improving the safety, quality, and quantity of seafoods. Such investigations include research and development of: (1) aquacultural techniques, particularly for shellfishes; and (2) processing machines and methods for handling underutilized species, for producing larger portions from each finfish or shellfish, and for ensuring safe and nutritious seafood products.

PERSPECTIVE

Since 1970, when the NEFC began operation, its activities have been oriented towards gathering information and providing advice for fisheries management. The development of the NEFC's fisheries research program started as a two-pronged process. First, the NEFC sought early estimates of what were the permissible yields of the major fishable stocks and of the total fishable biomass in the Northwest and Middle Atlantic. During the preceding decade a rapid increase in fishing effort, particularly by foreign fishermen, and a drastic decrease in the total catch and catch per unit of effort occurred for many species, including those of traditional interest to American fishermen in the Northwest and Middle Atlantic. Three-year (1973) and four-year (1974) periods, respectively, were the targets to find estimates of permissible yields. For the most part, these targets were met.

Second, the NEFC sought to understand those fundamental processes that control the size, composition, and structure of the total fishable biomass. Such knowledge would permit the prediction of future statuses of the biomass and its components. The NEFC set a 5-10 year period (1975-1980) as the target to attain these objectives. This target assumed a doubling of the research effort at that point, but a lack of funds prevented it. The first good understanding of these fundamental processes in fisheries production will now probably come by 1980-1985.

In this expansion from short-term studies for approximating allowable yields and on monitoring of changes in the resources, to long-term studies on understanding the fundamental processes of the ecosystem, the need arises for more information on those environmental factors, both natural and man-made, that affect fisheries resources. This expansion and resultant need for more information mesh well with the 1976 joining of the Middle Atlantic Coastal Fisheries Center's research program, which was environmentally oriented, with the Northeast Fisheries Center's research program, which was fisheries-oriented. This combined program can better respond to the need for information on both permissible yields and fundamental processes.

There is also a growing public concern for the health of the marine environment off the Northeast and Middle Atlantic States. This concern is based on: (1) the effects of pollutants on the survival, growth, and productivity of important marine populations; (2) the effects of pollutants on the safety of seafood consumed by humans or livestock; and (3) the potential of marine populations to concentrate and redistribute pollutants in the environment. Appropriately, NOAA is enlarging its efforts in these fields.

The NEFC is responding to these problems through a proposed program "Ocean Pulse." This program would combine the efforts of NOAA with many outside organizations, including the Energy Research and Development Administration and the Environmental Protection Agency, in order to identify, monitor, and analyze: (1) responses of marine organisms and populations to pollutants; (2) populations most critical to ecosystem stability; and (3) index species for overall environmental assessments. Unlike most past and present environmental impact studies that concentrate on specific pollutants within small areas for short times, the ocean health program would also conduct long-term studies over large areas. Such studies would determine the cumulative effects of sublethal concentrations of pollutants and gauge the ecosystem-wide impact.

As now envisioned, Ocean Pulse would study both polluted (dredge spoils, chemicals, acids, heavy metals, sewage, heat, pesticides, and oil) and unpolluted sites in the Gulf of Maine, Georges Bank, and Mid-Atlantic Bight ecosystems. Frequent sampling in these sites would reveal critical changes in the physiology, biochemistry, pathology, genetics, and behavior of indicator species, and in the populations of nekton, plankton, benthos, and bacteria.

As with the fisheries research program, this ocean health program must initially and immediately undertake monitoring studies. Such studies would provide the quickly needed answers on what are the effects of pollutants on living resources. The target date for these answers is 1980-1982. These short-term monitoring studies should rapidly blend into the long-term fundamental process studies, and into the continuing fisheries resource studies.

The following discussion of each component of the research program further defines the objectives mentioned above and indicates the contributions of each component towards meeting them. Figures 2 and 3 illustrate the structural and functional organization of the research program.

NATIONAL SYSTEMATICS LABORATORY

The National Systematics Laboratory is administered by the NEFC, but serves the entire Service. It studies the systematics of commercially, recreationally, and ecologically important marine organisms. Included in these studies are projects on taxonomy to facilitate the identification of species, on anatomy to document species classifications, and on the characterization of biogeographic complexes. Emphasized are epipelagic, deep pelagic, and benthic fishes; penaeid shrimps; and crabs and other decapods.

ATLANTIC ENVIRONMENTAL GROUP

The Atlantic Environmental Group supports the research programs of the NEFC and other NOAA components operating in the Atlantic Ocean by monitoring and studying environmental conditions and by analyzing environmental data acquired from various governmental agencies, private and academic institutions, and archives. Analyses performed by the AEG include portrayal and interpretation of oceanic and atmospheric data for environmental and fisheries forecasting. The AEG also develops techniques, models, and indexes for such forecasting. And, it advises NMFS's Office of Scientific and Technical Services, NOAA's

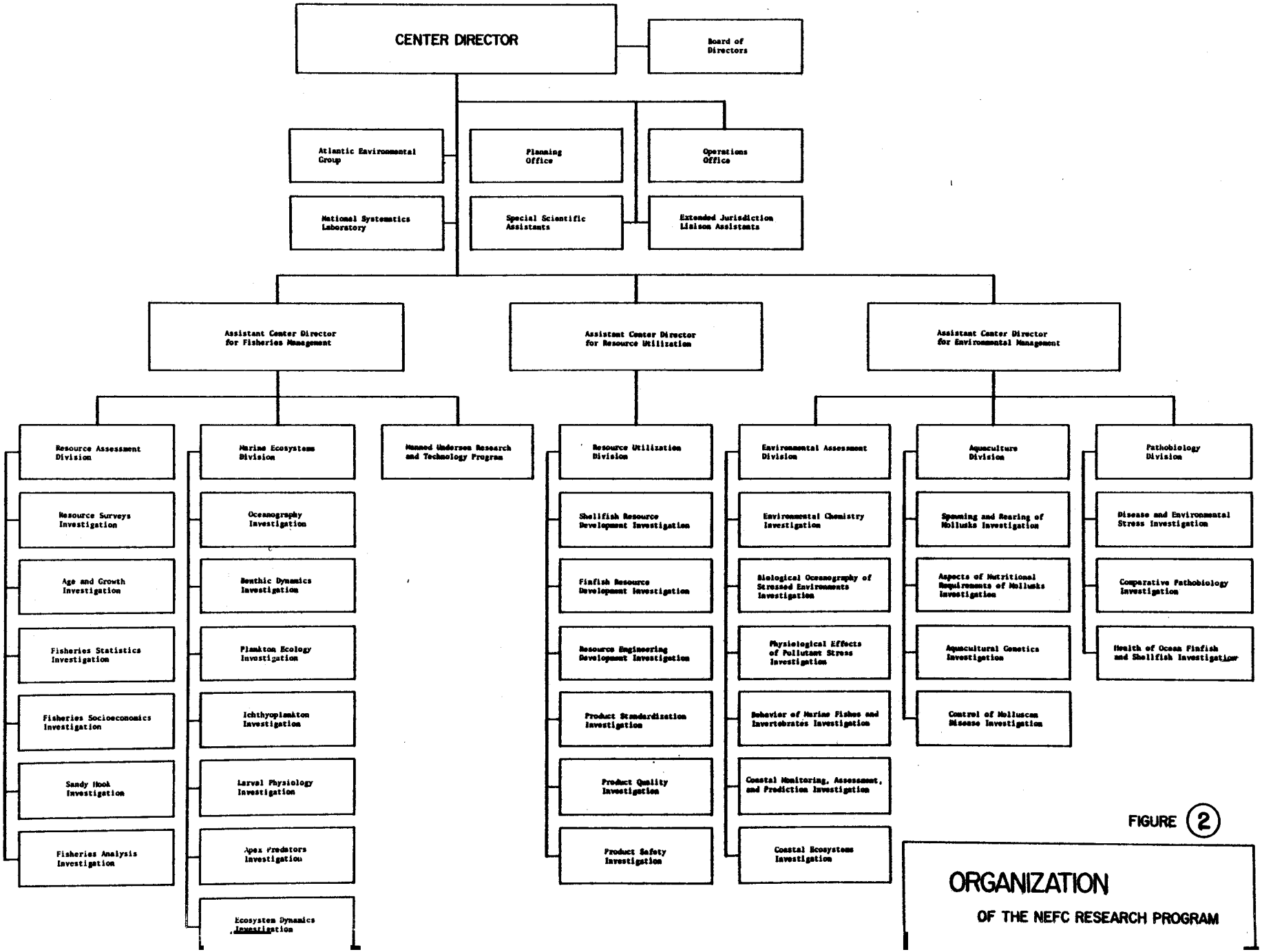

FIGURE 2

ORGANIZATION

OF THE NEFC RESEARCH PROGRAM

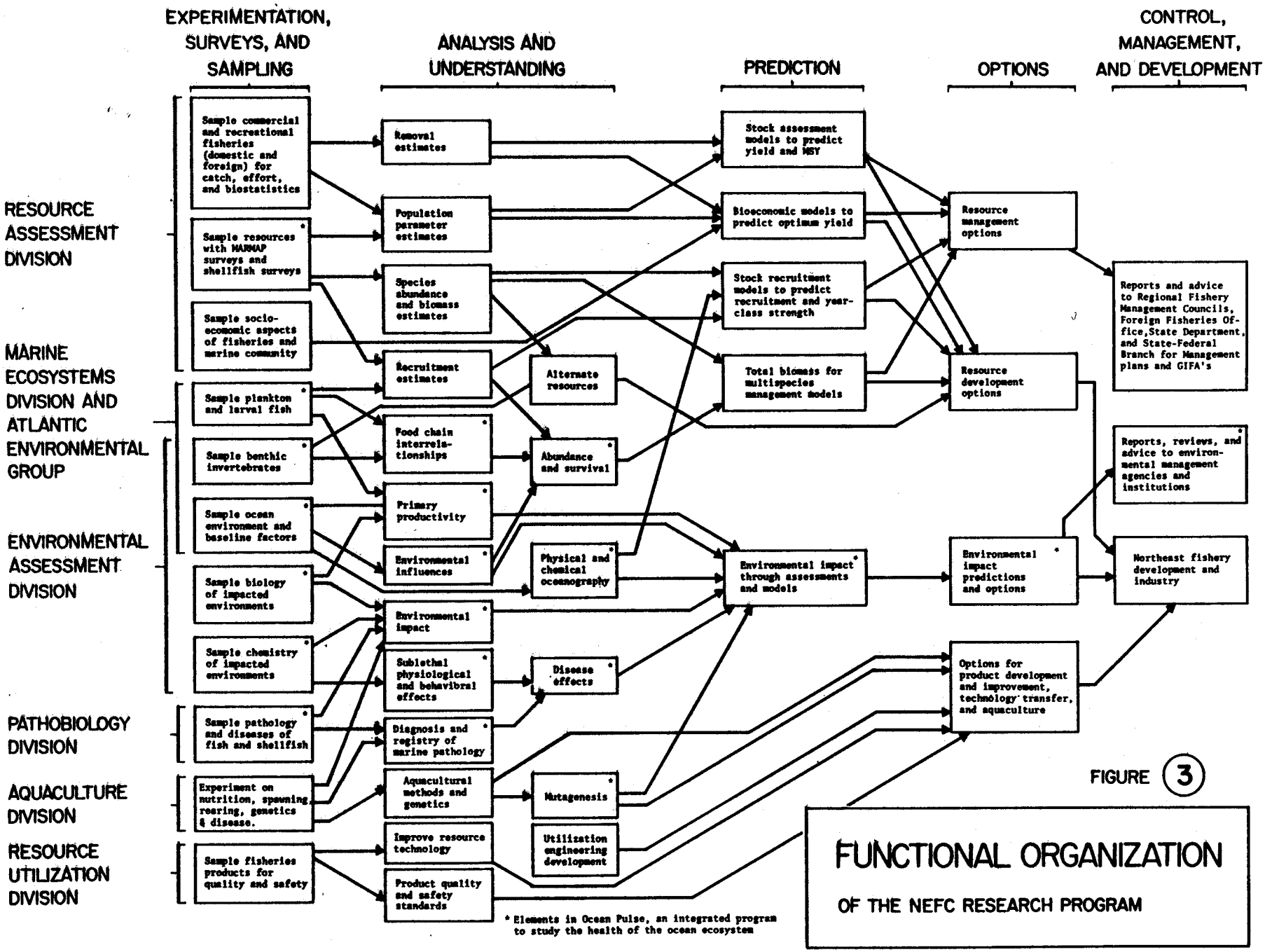

FIGURE 3

FUNCTIONAL ORGANIZATION

OF THE NEFC RESEARCH PROGRAM

Office of Marine Environmental Protection, and the National Ocean Survey's Ocean Dumping Research and Monitoring Office, on marine environmental studies.

RESOURCE ASSESSMENT DIVISION

The role of the Resource Assessment Division is to assess the effects of harvesting on fisheries resources. To do this assessment, the Division estimates the relative and absolute abundances; spatial and temporal distributions; and harvestable numbers, sizes, and weights of finfish, shellfish, and crustaceans in the Northwest Atlantic; and determines the productivity of these renewable marine resources from an ecosystem standpoint. To accomplish these tasks, the Division analyzes both domestic and foreign data from commercial fisheries, recreational fisheries, and research surveys. Additional economic and biological studies provide data for modeling the fisheries to aid in their management for optimum sustainable yield.

Resource Surveys Investigation

Each fall and spring the Resource Surveys Investigation surveys with bottom trawls the fisheries resources of the continental shelf from Nova Scotia to North Carolina. These surveys are part of the Marine Monitoring, Assessment, and Prediction (MARMAP) Program's Survey-II effort to document the relative abundance and distribution of these resources in the area. Supplementary surveys of the area occur regularly, many as cooperative efforts with other nations that fish in the Northwest Atlantic. These supplementary surveys often gather information that is not gathered in the semiannual surveys such as the seasonal/areal distribution of surf clams.

The standard data that are recorded on these various surveys are the length, weight, age, and maturity of the fish, and the temperature and depth of the water where captured. Ichthyoplankton samples and other hydrographic data are also often collected. Such data reveal changes in the size, composition, or structure of the fisheries resource. Some of the important species for which these data are collected are haddock, Atlantic cod, yellowtail flounder, silver hake, red hake, white hake, Atlantic herring, Atlantic mackerel, spiny dogfish, long-finned squid, and American lobster.

To complement the bottom trawl surveys, the investigation works on the development of hydroacoustical methods to survey pelagic fishes. Such work ranges from the study of the echo strength and pattern of a given size and species of fish, to the correlation of the hydroacoustical survey of an area with the actual net catches of fish from that area.

Finally, the investigation researches and develops systems for improving the efficiency of such surveys. One system currently under study will automatically log data while at sea. This automatic data logger records data systematically from on-board, automatic sensors, and stores them on magnetic tape in a form that can be directly interpreted by digital computers once on shore. Such a system permits an instantaneous correlation of biological data with physical and chemical data.

Age and Growth Investigation

The objective of this investigation is to determine species/stock growth rates and the age compositions of both the harvested and total populations. Information on this aspect of the population dynamics of various species/stocks is needed to assess productivities of species/stocks of the Northwest and Middle Atlantic. The investigation also works on the development of systems to aid in its research such as a computerized system for automatically determining age and growth from scales and otoliths. Among the species aged in this investigation are bluefish, butterfish, haddock, yellowtail flounder, Atlantic herring, Atlantic cod, silver hake, redfish, pollock, white hake, and Atlantic mackerel.

Fisheries Statistics Investigation

Fisheries statisticians perform both data reduction and data analysis. These data come from catch and effort statistics of research surveys and recreational and commercial fisheries, and from biological statistics of fish sampled in such surveys and fisheries. Foreign surveys and fisheries also contribute data for the reduction and analysis processes. With this information the investigation assesses the size, composition, and structure of the individual fish stocks and the total fish biomass of the Northwest and Middle Atlantic.

These assessments form the basis for a finer analysis. The investigational staff analyzes the effects of different fisheries management regimes such as optimum sustainable yield on the stocks and biomass. The researchers also evaluate the effects of different levels of catch and effort on the fishing mortality of a given stock. Since these analyses and evaluations often require the analysis and evaluation of the ecosystem as a whole, this investigation relies heavily upon other investigations for information on the various aspects of the ecosystem.

Fisheries Socioeconomics Investigation

The Fishery Conservation and Management Act of 1976 requires that the optimum sustainable yield of a fishery be determined by modifying the estimate of maximum sustainable yield by "relevant economic, social, or ecological factors." The Fisheries Socioeconomics Investigation establishes and maintains a socioeconomic data base and conducts the analyses needed to define optimum sustainable yields, surpluses, and allocations of fisheries resources to both commercial and recreational interests. The investigation develops economic profiles for various fisheries, including the economic value of the fishery, the recreational and commercial income of the fishery, and the capacity for harvesting and processing the catch. Econometric models are also constructed to evaluate the economic consequences of various management options. Sociological factors are a significant component of these models.

Sandy Hook Investigation

Several of the Resource Assessment Division's key people operate out of the Sandy Hook Laboratory. These people serve as a critical link to personnel and problems in the Middle Atlantic area by performing a variety of the duties with the Division in that area. Currently, these individuals are analyzing data from a creel survey of party and charter boats in New Jersey to estimate biostatistics from that important recreational fishery and to develop improved survey techniques. They are also monitoring specific fisheries, such as a study of the Middle Atlantic fisheries for the Atlantic cod and an investigation of fecundity and other biological parameters for the Atlantic mackerel and the Atlantic croaker. Sandy Hook individuals are also deeply involved in developing mid-water trawling procedures for monitoring inshore summer fish abundances.

Fisheries Analysis Investigation

This investigation focuses on modeling both the population and ecosystem dynamics of the commercially, recreationally, and ecologically important fishes in the Northwest and Middle Atlantic. Of the traditional fields of population dynamics -- population size, age-growth, mortality-yield, and stock-recruitment -- the first three undergo primary study by other investigations in the Division (Resource Surveys, Age and Growth, and Fisheries Statistics, respectively). The Fisheries Analysis Investigation integrates the results of these studies and primarily or secondarily investigates all four fields.

For the ecosystem dynamics approach, the staff considers the effects of natural and man-made environmental factors on interspecific competition and any resultant changes in the size, composition, or structure of the biomass. Socioeconomic interactions developed by the preceding investigation are also included in these fisheries models to aid fisheries managers in determining optimum yields.

MARINE ECOSYSTEMS DIVISION

Studies of the population dynamics of each species within a fishery do not by themselves provide the necessary information to manage effectively a multi-species fishery, especially one in which the sought-after species occupy different trophic levels. It is important to understand the population dynamics of individual species, but it is also important to understand the effect that the change in the distribution, abundance, and age structure of one species has on the other species in the ecosystem.

The 50 percent decrease in the number of finfish off the Northeast and Middle Atlantic States during the past decade, principally due to increased fishing effort, raises some significant questions. Does the reduction due to fishing of major predatory species such as Atlantic mackerel, haddock, Atlantic herring, yellowtail flounder, and Atlantic cod release major prey species such as certain zooplankters to be consumed by shorter-lived, faster-growing, smaller-sized, and less desirable predatory species? And, what are the probabilities of a return of over-exploited fish species to former abundance levels and former habitats?

Studies in the Marine Ecosystems Division address these questions. The studies focus on the critical links between the principal sources of fish food and the survival, recruitment, and productivity of the principal fish stocks sought after by fishermen. The availability of fish stocks to domestic fishermen is an end product of a complex series of events and interactions located: at the ocean bottom with the benthic food of groundfishes; in the water column with the zooplanktonic food of pelagic fishes; and in the changing physics and chemistry of moving water and weather conditions.

Ichthyoplankton Investigation

The Ichthyoplankton Investigation studies the community dynamics of larval fishes in the continental shelf waters from western Nova Scotia to northern North Carolina. To understand these community dynamics, the ichthyoplankton biologists try to determine, among other things, what factors control species dominance in larval fish communities. Two such factors under study at this time are the influences of competition within the larval fish community and of physical oceanographic events such as water currents, temperatures, and salinities. Based on such work the staff has the principal responsibility for preparing annual forecasts of changes in the abundance levels of the principal fish species in the area.

Another area of responsibility of the investigation is to coordinate the ichthyoplankton surveys of NOAA's Marine Monitoring, Assessment, and Prediction Program (MARMAP). This coordination involves interaction with both key American universities and state agencies participating in the program, as well as several foreign nations (Poland, Soviet Union, East Germany, and West Germany) participating in the program. The investigational staff serves in a liaison capacity and monitors the quality control of ichthyoplankton sorting in the Polish-American Plankton Sorting Center in Szczecin, Poland.

To aid in the aforementioned tasks, the staff develops taxonomic keys for the identification of larval fishes, prepares monographs on diagnostic features of fish developmental stages from egg through juvenile, and coordinates all NEFC taxonomic studies with the National Systematics Laboratory.

Benthic Dynamics Investigation

The Benthic Dynamics Investigation monitors and predicts changes in the kinds, abundances, and availability of food organisms for such bottom-dwelling fishes as Atlantic cod, haddock, and yellowtail flounder, and for such open-water fishes as Atlantic herring and Atlantic mackerel. The Investigation studies the consequences of such changes in benthic food organisms on the distribution and production of demersal and pelagic fish stocks in the Georges Bank, Gulf of Maine, and Mid-Atlantic Bight ecosystems. Staff members identify and enumerate important benthic food organisms, and define their environmental requirements and interrelationships with important fish stocks in the area. Another area of interest is the study of the trophodynamic relationships between pelagic and demersal species, focusing on the role of competition as a contributor to species dominance.

Plankton Ecology Investigation

The thrust of this research is the study of the influences of the abundance and availability of zooplanktonic prey on the major pelagic and demersal fish populations on the continental shelf, including such commercially, recreationally, and ecologically important fish stocks as the Atlantic mackerel, Atlantic herring, silver and red hakes, pollock, and sand lance. Specific research activities include: (1) the preparation of bimonthly indexes of zooplanktonic abundance from western Nova Scotia to Cape Hatteras; (2) investigation of the mesoscale and microscale relationships between zooplanktonic production and larval fish survival; (3) monitoring areal and seasonal changes in zooplanktonic prey availability along the migration routes of Atlantic herring and Atlantic mackerel as part of a study of the factors controlling areal and seasonal availability and abundance of the biomass of these stocks; (4) investigation of the impact of changes in the composition and abundance of the zooplanktonic biomass on the productivity of fish in the Georges Bank, Gulf of Maine, and Mid-Atlantic Bight ecosystems; and (5) monitoring effects of seasonal and annual changes of currents and water masses on the distribution and abundances of zooplankton and their predators.

In addition, staff personnel serve as the principal liaisons in the ongoing joint studies of secondary production with the Soviet Union, Poland, and West Germany, as well as oversee the operations of the Polish-American Plankton Sorting Center. The staff also develops and operates an electronic data processing system for quality-controlled data storage and analysis of zooplankton and ichthyoplankton data collected by the NEFC and other cooperating groups.

Larval Physiology Investigation

The Larval Physiology Investigation studies the energetics of larval fishes. Through laboratory experimentation and field studies the larval fish physiologists develop theories of larval growth and survival. Laboratory experiments look at, among other things, the effects of changes in the densities of zooplanktonic prey on the survival rates of larval fishes under controlled temperature conditions. Other studies focus on the linkages, both theoretical and actual, between the survival of larvae and the recruitment of harvestable-sized individuals into the fishery for such popular species as haddock, Atlantic cod, yellowtail flounder, winter flounder, and scup.

Apex Predators Investigation

This NEFC research effort looks at the effects of changes in the biomass of large predators, including sharks, tunas, and billfishes, on the commercially, recreationally, and ecologically important stocks of finfishes in the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight ecosystems. Species-specific studies of apex predators deal with age-growth relationships, mortality rates, population recruitment, migratory behavior and patterns, and trophodynamics

as they relate to requirements for growth and reproduction. The investigational staff works closely with fishermen by: (1) conducting extensive tagging experiments in cooperation with recreational and commercial fishermen from Maine to North Carolina; (2) serving as the principal liaison between the NEFC and recreational fishermen in the same region; and (3) monitoring the annual changes in abundances of certain shark populations through in-depth studies of catch data from fishing tournaments conducted off the Northeast and Middle Atlantic States. In addition, the staff coordinates cooperative studies on apex predators with other governmental agencies, private groups, and foreign countries such as Poland, Canada, West Germany, and the Soviet Union.

Oceanography Investigation

Migrations of fish are not random, but are initiated and guided by environmental cues. Although fisheries scientists have been moderately successful in describing the movements of pelagic and demersal species in response to environmental changes, they have been less successful in forecasting the specific times and places (patterns) of fish movements. To forecast such fish movements, the Oceanography Investigation monitors currents, temperatures, salinities, and movements of water masses and water types to understand the influences of such oceanographic conditions on movements of those species that contribute significantly to the fish biomass (Atlantic herring, Atlantic mackerel, Atlantic cod, etc.). Research focuses on those environmental conditions that optimize survival and growth of the dominant finfishes in the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight ecosystems.

Observations are made on two scales, mesoscale and microscale. The mesoscale MARMAP surveys from western Nova Scotia to Cape Hatteras occur six times a year. Such mesoscale observations are made at sufficient intervals to monitor the movements of such fishes as the Atlantic herring, Atlantic mackerel, and Atlantic cod, and their zooplanktonic prey. Microscale studies are conducted within a given water mass to define the oceanographic factors controlling the dispersal and survival of fish eggs and larvae at selected spawning sites. Even slight changes in the transport of larval fishes by currents can influence the size of a species' entire incoming year class. Studies are also conducted on the effects of warm-core rings from the Gulf Stream and fluctuations in slope water on the oceanography of the three ecosystems mentioned above.

The investigational staff also serves as the principal liaison between NEFC fisheries oceanography studies and cooperative investigations conducted with other governmental agencies, private groups, and foreign nations (Soviet Union, West Germany, East Germany, and Canada). Additionally, periodic reports of anomalous oceanographic conditions are provided to the fishing industry and other interested parties.

Ecosystem Dynamics Investigation

This investigation develops recruitment models for both pelagic and demersal fish species, including haddock, Atlantic cod, yellowtail flounder, Atlantic herring, and Atlantic mackerel. Models of larval fish behavior are also developed to assess the effects of variations of larval and juvenile growth and mortality on these stock-recruitment relationships. The information generated by these studies permits the development of candidate models of the marine ecosystem. The models are then compared with the empirical structure, standing crop, and production of specific finfish and benthic invertebrate communities. The models of selected population processes and biological interactions are used to provide practical advice to fisheries managers in the Northwest and Middle Atlantic.

Multispecies models are developed that take into account the energy requirements of the major fish populations under different simulated management regimes. These studies will lead to the development of more efficient management strategies for dealing with the three principal marine ecosystems of interest, the Gulf of Maine, Georges Bank, and the Mid-Atlantic Bight. Initial emphasis is on the development of a mass energy model for Georges Bank. Refinements of this model will be made over the next several years.

MANNED UNDERSEA RESEARCH AND TECHNOLOGY PROGRAM

The Manned Undersea Research and Technology (MURT) Program functions as both an autonomous and support research group. MURT deals with sampling needs and ecological studies that are difficult, costly, or impossible with conventional surface research vessels. MURT's dive team works to: (1) develop an efficient research diving capability to and beyond the edge of the continental shelf with conventional and advanced diving technology and research submersibles; (2) survey the macrobenthos of the outer continental shelf; (3) study *in situ* the early life stages of Atlantic herring and the ecological factors affecting their eggs and larvae; (4) define the sampling efficiency of standard surface-oriented sampling hardware; and (5) monitor the abundance and ecology of bottom-oriented fauna and flora at specific locations on the New England continental shelf as an index to ocean health.

RESOURCE UTILIZATION DIVISION

This major NEFC research component assists the American fishing industry and consuming public in increasing the quantity and improving the quality of finfish and shellfish products. By working closely with representatives of the fishing industry and consuming public, the Resource Utilization Division applies available technology towards increasing the production of commercially processed fish and finds ways to use the large variety of relatively unused marine species. To improve the quality of seafoods and assure their safety, staff members study the changes that occur during storage, and design various handling, processing, and preservation techniques that reduce adverse changes and enhance desirable characteristics in the product. The Division also coordinates the fisheries engineering and conservation gear development programs within the NEFC.

Shellfish Resource Development Investigation

The primary purpose of this Investigation is to develop new or modified methods of handling, processing, and preserving shellfish for increasing yields and improving economics. Current activities include the development of: (1) a new technique for roller extraction of crabmeat that covers all phases of processing and product quality; (2) a method for identifying crabmeat to species; (3) handling and processing methods for underutilized offshore crab species (red crab, rock crab, and Jonah crab); (4) a test to determine the amount of shell fragments in crabmeat; and (5) more efficient processing methods for squid including handling at sea, grading, skinning, eviscerating, stripping, and new product development. A secondary purpose of the Investigation is to provide technical advice to the blue crab and oyster industries.

Finfish Resource Development Investigation

This Investigation attempts to develop or modify methods of handling, processing, and preserving all types of finfish for increasing yields and improving economics. The Investigation contracts with industry to evaluate the effectiveness and commercial potential of prototype machines to handle silver hake, or whiting, that are smaller than can now be processed economically.

Another study seeks to upgrade the value of silver hake by developing new products and new product forms. Studies of three new silver hake products are currently underway. The investigation guarantees some fresh New England fillets as "U.S. Grade A" to determine the effort needed to assure consumers of quality, how much consumers will pay for the guarantees, and the cost of such guarantees. Other tasks include research into the effects of feeding animals with irradiated fish, and on the future of irradiators in fish preservation.

Resource Engineering Development Investigation

This Investigation is a mechanical engineering support of fisheries development activities. Since there are presently no mechanized processing lines for underutilized species like silver hake, long-finned squid, red hake, goosefish, and ocean pout, the staff adapts and modifies presently available machines or designs and builds new machines to accomplish this task. Ongoing projects include: (1) developing a device to meter additives to minced flesh; (2) designing and building a machine for eviscerating and skinning squid; (3) designing and building a machine for grading any species into several size categories; and (4) designing and building a machine for sorting a mixed bag of fish into three selected size categories. This Investigation is also concerned with the development of fishing gear to improve efficiency, selectivity, and safety, and to protect the quality of the catch. Typical developments include a quick-release branchline clip for longlining, an improved trawl door hook-up, a trap that discontinues its ability to operate when it is lost, and a removable deck-block mounting pad.

Product Standardization Investigation

The development of standards and specifications of quality for fisheries products is the principal goal of the Product Standardization Investigation. Current efforts involve the development of standards for minced fish blocks, shrimp, and fillets, and fulfilling assignments for the "Codex" international standards as designated by NMFS. Standards are developed according to the following steps: (1) conduct an industry survey; (2) prepare a draft of proposed standards and distribute to interested parties; (3) resolve any comments and publish the proposed standards in the "Federal Register;" (4) after amendment of the proposed standards based on the comments, republish them in the "Federal Register;" and (5) upon finalization of the standards, make available instructions and other inspection aids for using them. Another goal of the Investigation is to recommend or develop if necessary standardized analytical procedures for evaluating the criteria of the standards.

Product Quality Investigation

This Investigation tries to solve the problem of quality deterioration of fisheries products that results in resource and economic losses. The diminishing supply of frozen Atlantic cod blocks has stimulated industry interest in minced silver hake as a substitute. However, minced silver hake can become rancid and tough during frozen storage. This task minimizes this quality deterioration through proper packaging, storing at optimal temperatures, using chemical additives, or combinations thereof. Certain parameters such as fat content which vary seasonally are studied to determine their effects on storage stability. Because the mincing operation provides an excellent chance for microbial contamination, surveys are made on the microbial and organoleptic qualities of commercially minced blocks to aid in establishing standards.

Product Safety Investigation

Within this study investigators determine the possible chemical hazards in fisheries products that can result from processing or environmental conditions. One class of chemicals under study is the volatile N-nitrosamines, potent carcinogenic compounds that have been found in many varieties of cured foodstuffs ranging from pork products to fish. These chemicals are formed by the action of nitrite preservatives on amines occurring naturally in food. Marine fish can contain significant quantities of amines which can react with nitrites encountered either during processing or possibly from industrial contamination of their environment. In previous N-nitrosamine studies, hot-smoked sablefish, hot-smoked salmons, and hot-smoked whitefishes were tested to determine the effectiveness of sodium nitrite in inhibiting the outgrowth and toxin production of the bacterium *Clostridium botulinum*, types A and E. After defining the inhibitory range of sodium nitrite, more detailed experiments were conducted to show the minimum level of nitrite needed to inhibit the bacterium. Samples from these experiments are now being analyzed by a multidetection method that identifies 14 volatile N-nitrosamines found in foods.

ENVIRONMENTAL ASSESSMENT DIVISION

This NEFC effort concentrates on the physical, chemical, and biological interactions which affect the estuarine, coastal, and marine environments of the Northwest and Middle Atlantic. Research stresses the impact of man's activities on the productivity and biomass of benthic, demersal, and pelagic organisms. The Division emphasizes the effects of these activities on the interrelations between biotic and abiotic elements of the environment. Results of these studies document the impact of man on commercial and recreational stocks and their forage species. Behavioral, physiological, and biochemical studies determine both subtle shifts in normal behavior and biological processes which can indicate sublethal but significant damage to resource reproduction, recruitment, feeding, migration, and other activities.

Environmental Chemistry Investigation

This Investigation studies the temporal and spatial distributions of toxic chemicals, their environmental life spans, their cycles through food chains, and their effects upon the biology, habitats, and uses of marine resources. Emphasis is currently on heavy metals and petroleum-derived and halogenated hydrocarbons like DDT and PCB's. To monitor the presence of trace metals, routine measurements of their concentrations are taken in various finfish and shellfish species from intertidal and coastal waters; in apex predators collected from Deepwater Dumpsite 106; in water; and in sediments, organic debris, and other solid components of the marine environment. Measurements are also taken of trace metals in various tissues, gametes, and other cell types from organisms exposed to known lethal and sublethal levels of toxic metals. The hydrocarbon research consists primarily of the measurement of petroleum-derived and halogenated hydrocarbons in Middle Atlantic and Gulf of Maine species in waters contaminated by urban, industrial, and agricultural wastes and runoffs. The data gathered by this effort are used to model the movement of these potentially toxic materials through benthic, demersal, and pelagic food webs.

Biological Oceanography of Stressed Environments Investigation

The objective of this study is to determine the effects of urban areas upon adjacent estuarine, coastal, and marine ecosystems and their species. This program began in the Lower Hudson Estuary and New York Bight Apex and has expanded to cover the entire continental shelf from Cape Hatteras to Georges Bank. Studies under various conditions of river flow, temperature, planktonic blooms, and metabolic activity will show the extent and magnitude of the effects of New York City and other metropolitan areas on continental shelf waters. The investigation studies phytoplankton productivity and standing stocks, species ecology and diversity, nutrient levels, hydrography, rates of water column and seabed oxygen consumption and organic matter decomposition, bacteriology, and contaminant identification. Surveillance and laboratory activities stress the frequent recurrence of phytoplankton blooms. Emphasized in these activities are nutritional and physiological capacities of causative organisms, and phytoplankton succession and bloom development in response to nutrient supplies from pollution.

The work of the Investigation is broken up into four different, but interrelated efforts. First are studies of production rates, photoassimilated-carbon cycles, and phytoplankton standing stock variations. The investigational staff relates the data from these studies to man-made and natural sources of nutrients and pollutants in the Mid-Atlantic Bight. Ultimately, this research will define the relationships between primary productivity and the abundance of finfish and shellfish resources on the one hand, and between waterborne toxins and the distribution of such resources on the other hand. Second, analyses take place on the causes and effects of plankton blooms. Among these analyses are studies of the macronutrient and micronutrient requirements of dinoflagellates involved in red tides, fish kills, and other bloom-induced phenomena. The Investigation monitors and describes such plankton blooms and associated physical and chemical factors to determine the impacts upon various marine resources. Third, the staff looks into oxygen utilization by sediments and waters polluted with such organic materials as sewage sludge, dredging spoil, and petroleum. The uptake rates are correlated with temporal and spatial distributions and standing stocks of benthic, demersal, and pelagic organisms. And fourth, the investigation determines the cell numbers and identities of significant aerobic bacteria in the Mid-Atlantic Bight. Such determinations qualitatively document the health of this ecosystem and reveal the functions of microorganisms in the marine environment. The metabolic rates of this heterotrophic activity are compared, particularly on a long-term basis, with the presence of various organic contaminants and the occurrence of various environmental factors.

Physiological Effects of Pollutant Stress Investigation

This Investigation determines how and to what degree pollutants, individually and in combination, affect various marine animals at different life stages. New laboratory rearing techniques permit studies of pollutant effects upon embryonic, larval, and juvenile stages, as well as upon the adult stage which has been the focus of most past research.

The gradual reduction or elimination of a species by sublethal levels of pollutants is no less serious than the demise caused by lethal levels. Possibly it is more serious, since sublethal effects are less likely to be detected and traced to their source before irreparable damage has occurred. The decreased productivity of fish stocks due to sublethal pollutant exposures that impair growth, reproduction, and survival is a principal concern of this investigation.

These effects are slow and do not cause immediately obvious changes in populations, but cause subtle alterations in physiological functions and behavior that affect migration patterns, responses to temperature change, egg viability, and/or growth rates. The results are slow changes in reproductive rates and population sizes. Because chemical contaminants occur in the marine environment at higher concentrations than those that have been shown to cause adverse effects in the laboratory, it is probable that these pollutants are now adversely affecting the productivity of important fish, shellfish, and crustacean populations.

Accordingly, staff members research the physiology and biochemistry of selected species of marine animals common to the Mid-Atlantic Bight and other Northwest and Middle Atlantic environments, and determine experimentally the effects of heavy metals on their survival, development, and normal life functions. They have established tolerance ranges and the sublethal concentrations at which metabolic disturbances can be detected in embryonic, larval, juvenile, and adult stages of mollusks, crustaceans, and finfish, particularly those of commercial, recreational, and ecological importance. Biological models may be useful in future evaluations of pollutant-related stresses in marine environments, and this investigation will provide the necessary input for these models.

This Investigation is also concerned with those microorganisms capable of growing under reduced oxygen tension (anaerobic conditions) in the fisheries environment and on living marine resources. The major goal is to determine the presence of pollutant and disease-producing anaerobes in the fisheries environment, their persistence and cycling through the food chain, and other possible interrelated toxin transfer mechanisms and chemical conversion mechanisms which can adversely affect fish stocks and their habitats.

Behavior of Marine Fishes and Invertebrates Investigation

To define the physical, chemical, and biological requirements of marine fishes, this Investigation studies species behavior and ecology in both the field and laboratory. Research concerns the role of various environmental factors in the life habits of selected species, how man-made and natural modifications of the environment affect those life habits, and the capabilities of species to detect and avoid potentially lethal conditions. Field studies focus on feeding habits, habitat requirements, relationships with different substrates, seasonal patterns of activity, distributions, and interspecific and intraspecific relationships of such inshore demersal species as tautog, cunner, and winter flounder. These studies help to define life habits and environmental requirements of various life stages of each species. Laboratory researchers record normal activity, feeding, and social behavior (aggression, territoriality, and reproduction) in such species as adult tautog, cunner, red hake, juvenile bluefish, and other finfish, as well as physicosensory and chemosensory responses in such brachyuran crustaceans as blue crabs. Data from this research define the effects of environmental conditions and stresses on life habits, recruitment, and survival. Another task pools previous research findings on normal behavior to gauge the effects of selected environmental stresses on schooling, feeding, and activity in juvenile striped mullet and bluefish, and on territoriality, feeding, reproduction, and activity in adult tautog and brachyuran crustaceans.

Coastal Monitoring, Assessment, and Prediction Investigation

The Coastal Monitoring, Assessment, and Prediction (COMAP) Investigation routinely surveys the fish, plankton, and benthos of the inner coastal region (20-100 meters in depth) from Block Island Sound to the Bay of Fundy. Among other things, these monitoring surveys assess the impact of man's activities on the inshore environment and its organisms. Specifically, staff members make these assessments by noting changes in the distribution and relative abundance of fish and invertebrate species in response to changes in the physical and chemical environment. These environmental changes range from oil spills, to thermal pollution, to disposal of dredging spoils. Investigators also collect data on recruitment mechanisms for such commercially important species as American lobster, Atlantic herring, Atlantic mackerel, and winter flounder. They also assess the inshore distribution and relative abundance of species sampled semiannually in NEFC offshore bottom trawl surveys.

A significant and increasing portion of COMAP activities involves serving as an NEFC liaison to individuals and groups (such as the New England Fisheries Development Program) with diverse interests in inshore waters. COMAP cooperates with outside scientists in assessing fish stocks off the Northeast and Middle Atlantic States, and reviews research proposals by the private sector for siting and impact studies for power plants, dredging spoil disposal areas, and other operations that could potentially adversely affect fish stocks and other renewable marine resources.

Coastal Ecosystems Investigation

The major objective of this Investigation is to collect baseline geological, physical, chemical, and biological data to assess changes in benthic and demersal populations in Long Island Sound, Gulf of Maine, and Mid-Atlantic Bight estuaries and coastal zones. The program is integrated among state, interstate, and other federal research organizations. In the estuarine research, the investigation emphasizes population studies. Long Island and Block Island Sounds, Raritan and Delaware Bays, and numerous smaller embayments of the Mid-Atlantic Bight are the primary study areas. The investigational staff works on the interrelationships between various benthic and demersal species that live all or part of their lives in the estuaries. The staff also models the pollutant pathways from contaminated embayments to coastal zones.

In the separate but related research on coastal zones, the Investigation studies those offshore populations in the Mid-Atlantic Bight that are affected by ocean disposal of sewage sludge, dredging spoils, and industrial wastes; by energy development; and by riverine runoff from the Hudson and Delaware Rivers. This population information helps to document the causes and effects of extensive coastal anoxic conditions. The investigation also compiles data on contamination of Northwest and Middle Atlantic waters by various bordering states, and provides this information to various international organizations involved with the fisheries resources and water quality of the area.

AQUACULTURE DIVISION

The effects of nutrition, pollutants, and genetic processes upon growth and survival of commercially important marine species are the research responsibility of this Division. Studies concern the algal food nutrition, genetic selection, and disease and predator control associated with larval molluscan culture.

Spawning and Rearing of Mollusks Investigation

Oyster culture methods are adapted for the hatchery cultivation of other commercially important bivalves. This research and development program progresses logically from gametogenesis, through spawning the adults, rearing the larvae and growing the post-set stage immediately after metamorphosis, to growing the juveniles. The bay scallop and surf clam are currently being studied because of their potential for aquaculture.

Aspects of Nutritional Requirements of Mollusks Investigation

A priority of the research into commercial aquaculture methods is the development of a economical and nutritional supplement to the diets of animals in an aquacultural program. The investigation contributes to that cause by: (1) assisting in problem solving; (2) introducing innovative procedures; (3) studying phytoplankton food-chain organisms; and (4) researching molluscan food utilization. Another task is the support of all the molluscan research projects by providing a high quality and large quantity of algal food.

Aquacultural Genetics Investigation

This Investigation develops genetic information to answer the questions of industry on how to develop profitable strains of hatchery shellfish. The investigation also advises industry on various aspects of aquacultural breeding without specific requests. A major goal of the program in aquacultural genetics is the creation of special gene pools at NMFS laboratories or under NMFS auspices. Industry and consumers would benefit from the improved management of wild shellfish beds that would result from the increased knowledge of the genetic potentials of wild shellfish populations based on studies of the special gene pools.

Control of Molluscan Disease Investigation

This investigation's work is an integral part of the NEFC's research on shellfish aquaculture. However, by the nature of the scientific expertise needed to conduct the Investigation's research activities, the research is supervised by the Pathobiology Division. Thus, two Divisions are directly involved in this investigation.

Molluscan disease research focuses on the prevention, diagnosis, and control of disease, particularly in hatcheries and nurseries. Objectives are to: (1) monitor, isolate, identify, and culture micropathogens, and characterize their pathologic effects; (2) determine mechanisms of micropathogen transmission, penetration, infectivity, and host specificity; (3) study qualitatively and quantitatively micropathogen activity and host responses; and (4) evaluate the use of various chemicals including ozone gas to deactivate biotoxins and control micropathogens. A primary use of these methods is in the study of diseases of larval mollusks. The Investigation seeks to develop physical methods, including ionization, to eliminate microbial pathogens and toxins in larval mollusks. The investigators on this project also provide consultation to industry and Sea Grant institutions involved in aquaculture.

PATHOBIOLOGY DIVISION

The Division works with all aspects of diseases, infectious and noninfectious, biotic and nonbiotic, that affect marine resources. Not only is there an emphasis on the impacts of diseases on marine populations, but also on the influence of natural and man-made environmental factors on the occurrence of those diseases.

Disease and Environmental Stress Investigation

Disease, environmental changes, and pollutant stress act synergistically with those factors that induce death in marine poikolotherms. For this reason the Investigation studies the pathologic effects on marine organisms caused by natural and man-made changes to marine ecosystems. Such man-made changes include habitat modification by ocean waste disposal, dredging activities, recreational activities, and petroleum development. Field and laboratory research establishes the causes of death, abnormality, and tissue and cellular pathosis (anatomical, physiological, and biochemical) in the affected marine organisms. The Investigation concentrates on five specific research topics to achieve these goals. First, fin rot disease is studied in the New York Bight. Researchers try to determine the prevalence and pathogenesis of fin rot in winter and summer flounders in the bight. Trawl surveys and entrapment studies provide the diseased specimens for histopathological examination. Second, immunity in marine fishes is researched. The two principal goals of this study are to determine whether pollution reduces the immunity of fishes to bacterial disease, and to correlate fish diseases with raised levels of serum antibodies for specific bacteria in the fishes. The study operates through examination of antibody responses and cellular defenses of fishes in both the field and the laboratory. A variety of immunological and cytochemical tests analyze systems of fish immunity under the combined stress of pollutants and bacteria. Third, the microstructure of normal and physiologically stressed crabs, fish, and mollusks is studied. Normal and pathologic tissues of such species as blue crabs, winter flounder, striped bass, and Atlantic mackerel are studied by electron microscopy. In addition to examining organisms with naturally occurring diseases, the staff also conducts experiments on new pathological and immunological procedures. Fourth, the investigation catalogues, maintains, and provides curatorial and custodial services for a permanent National Registry of Marine

Pathology. This registry contains type specimens, photographs, and published literature on pathology in marine and estuarine poikilotherms. Additions to the registry are gathered by solicitation of the scientific community. Materials are available for study by qualified scientific and technical workers. And fifth, diseases of commercially and recreationally important fish species are studied histologically. The first objective of this research is to determine the causes of mortality in various fishes. The second objective is to analyze the lethal and sublethal effects of introduced chemical contaminants upon various species and life stages of fish.

Comparative Pathobiology Investigation

Infectious and noninfectious diseases limit the abundance, distribution, and utilization of marine organisms. Therefore, a knowledge of the causes and effects of these diseases is fundamental for successful management of fisheries resources and habitats. In this Investigation, normal and abnormal organs, tissues, and cells are intensively observed for comparative histology, cytology, and epizootiology. Light and electron microscopy reveal pathologic conditions induced experimentally, occurring naturally, or found in aquacultural processes. Micropathogen activities are defined and described quantitatively and qualitatively and infectious agents and microparasites are identified and characterized.

To achieve these goals one of the first steps is to study the health status of mollusks, crustaceans, and fish. For mollusks, the Investigation studies the microstructure of tumors, describes the morphology and cytopathology of oyster viruses with light and electron microscopy, and describes the microparasites of domestic and exotic species. For crustaceans, most of the effort is on blue crabs, rock crabs, and shrimp. Research on the crabs involves: (1) the study of the epidemiology of viral infections; (2) the study of the transmission mechanisms of protozoan viruses, and of such protozoa as Paramoeba; and (3) the preparation of an atlas of blue crab histology. With respect to shrimp, other crabs, and lobsters, the staff concentrates on the pathobiology of the exoskeleton and gills.

Another area of study within the Investigation concerns the microfauna associated with fish, crustaceans, and mollusks. Staff members isolate and identify the protozoa of both the water column and sediments of the New York Bight, identify gill-fouling organisms of New York Bight crustaceans by microscopic examination of stained gill sections, and determine the prevalence of sporozoan parasites in the blood tissues of Atlantic mackerel and of other parasites in other fish.

Health of Ocean Finfish and Shellfish Investigation

The integrity of oceanic ecosystems is directly reflected in the health and well-being of their inhabitants. Except in the most unusual circumstances, the presence of healthy animals signifies a healthy environment and vice versa. Thus, the purpose of this Investigation is to assess comparatively the health of several selected target species of ocean fish, crustaceans, and mollusks from selected ocean sites.

The presence and abundance of infectious microorganisms (viruses, bacteria, and protozoa), some of which also produce highly toxic substances, are magnified in unbalanced ecosystems. These organisms can cause disease and abnormalities among resident species either directly or indirectly as secondary invaders acting in concert with other environmental stresses. Similarly, the health of ocean species can be profoundly affected by man-introduced noninfectious agents, such as petroleum and its byproducts, various agricultural and industrial pollutants, and substances leached from dredged materials.

Approaches used to ascertain the health of target species will include: (1) studies of fish immune systems to determine if the animals produce the necessary defense mechanisms to combat or overcome disease (that is, these mechanisms operate normally and how they are affected by natural and man-induced stresses); (2) observations on the prevalence of gross and microscopic lesions and descriptions of same on the tissue, cellular, and subcellular levels, using light and electron microscopy; (3) cytochemical and clinical chemical analyses of cellular and humoral responses to infectious and noninfectious diseases; and (4) use of microbial and cellular systems (bacteria, fungi, and animal cell lines) for mutagenic and carcinogenic assays and for indicators of pollution (viruses, bacteria, and protozoa).

LABORATORIES

WOODS HOLE LABORATORY

The Laboratory brackets the corner of Water and Albatross Streets in Woods Hole, Massachusetts. Situated on the southwestern tip of Cape Cod, the facility overlooks the Woods Hole Passage, a narrow channel between Buzzards Bay on the west and Vineyard Sound on the east. Nearby transportation includes the Hyannis Airport (25 miles), the Woods Hole Bus Depot (1 mile), and Massachusetts Route 28 (via Woods Hole Road).

The three-acre complex holds three buildings (main building, aquarium-maintenance-net loft building, and age-growth building) and a wharf. Additionally, office space is leased in an adjacent building of the Marine Biological Laboratory, and storage space is available in two buildings at nearby Otis Air Force Base.

Special research facilities include 50 aquaria that range to 3,000 gallons in capacity. The aquarium-maintenance-net loft building houses most of these aquaria and constantly supplies filtered, recirculated, temperature-controlled seawater to them. Research in the aquaria concentrates on individual, intraspecific, and interspecific behavior and relationships.

The MURT program (see discussion of research program) maintains a five-foot, double-lock recompression chamber to support NEFC diving activities. The chamber is not available to the general public since medical personnel trained in such work are not locally available.

The Laboratory is also the home port for one of the NEFC's two oceangoing fisheries research ships, the ALBATROSS IV. The 187-foot, 939-ton ship has a cruising speed of 11 knots, endurance of 14 days, and range of 9,000 miles. The personnel capacity is 13 scientists and 23 officers and crew. There are one electronics, one hydrographic, one chemistry, and two biological laboratories. Standard measurements and collections taken on board the ALBATROSS IV are hydrographics, hydroacoustics, benthic invertebrates, plankton, and groundfish and associated species.

The Laboratory's library has 300 journals or other serials (bound in 6,000 volumes), 2,000 books, and 7,000 other catalogued items. Major subjects are fish and fishery biology, fishery management, fishery statistics, marine biology, oceanography, and marine management and law. Laboratory personnel have access to the adjacent libraries of the Marine Biological Laboratory and the Woods Hole Oceanographic Institution.

NARRAGANSETT LABORATORY

Located on South Ferry Road in Narragansett, Rhode Island, the Laboratory borders the western shoreline of Narragansett Bay--one of the Northeast's largest and most ecologically important estuaries. Nearby transportation includes the Greene State Airport in Warwick (25 miles), Kingston Railroad Station (5 miles), Providence Railroad Station (30 miles), Kingston Bus Depot (5 miles), Providence Bus Depot (30 miles), and Interstate 95 (via Rhode Island Route 138 from the south, or Rhode Island Routes 2 and 4, U.S. Route 1, and Rhode Island Route 1A from the north).

The Laboratory, five trailers, and a storage shed occupy the three-acre complex. Two additional buildings at the Davisville naval facility furnish additional storage space.

Special research facilities include a sophisticated research aquarium with two large tanks (15,000 and 8,000 gallons), four small tanks (each 280 gallons), a constant-temperature room, and a plankton-rearing room with several 10-gallon, temperature-controlled aquaria for rearing larval fish. Six major laboratories have an extensive collection of specialized instrumentation. These instruments include an automatic plankton sorter, respirometers, bomb and adiabatic calorimeters, and carbon analysis equipment.

A small library collection of journals and other serials, books, and miscellaneous items serves the scientific staff as an internal source of information. Laboratory personnel have access to the Main Library and Pell Marine Science Library of the University of Rhode Island (URI). The latter library has 6,000 monographs, 800 journals or other serials bound in 8,000 volumes, and 16,000 reprints. Major subjects are oceanography, marine biology, and fisheries. The URI libraries also possess a special collection of reports on the principal marine and polar expeditions.

GLOUCESTER LABORATORY

The facility, located on Emerson Avenue in Gloucester, Massachusetts, rests on the southern shore of Cape Ann--a point separating Massachusetts Bay from the Gulf of Maine. Nearby transportation includes Boston's Logan International Airport (35 miles), Gloucester Railroad Station (1 mile), and Massachusetts Route 128 (1 mile). Four buildings (main building, marine products irradiator building, Jones and Hunt Building, and fish house) comprise the Gloucester Laboratory.

In addition to the irradiation unit and fish house (the latter consists of six fiberglass tanks that are supplied by two independent systems of filtered/refrigerated/recirculated water), the Laboratory has an extensive collection of instrumentation. Among these instruments are gas chromatographs, advanced electrophoretic equipment, recording spectrometers, an analytical ultracentrifuge, and an autoanlyzer. There are two pilot plants with various food processing apparatuses, a microbiology laboratory, biochemistry laboratories, a machine shop, a carpenter shop, and seven large walk-in storage chambers that operate under the most advanced environmental control system.

Currently, the Laboratory's library has 55 journals or other serials and 1,600 nonserial holdings. Fields of concentration are chemistry, food technology, standards and specifications, nutrition, microbiology, and marine biology.

SANDY HOOK LABORATORY

The Sandy Hook Laboratory, located within the Gateway National Recreation Area of Highlands, New Jersey, rests at the tip of Sandy Hook, a peninsula separating Sandy Hook Bay from the Atlantic. From Newark Airport (40 miles) the Laboratory is reached via the New Jersey Turnpike south to the Garden State Parkway south to U.S. Route 36 east.

Four buildings (main building, two annexes, and a dormitory) comprise the Sandy Hook Laboratory.

Special research facilities include an aquarium which has a 32,000-gallon tank and several smaller (30-3,000-gallon) tanks. The large tank incorporates a complete environmental-control system that permits highly sensitive behavioral studies to be conducted.

One of the two major oceangoing fisheries research ships of the NEFC, the DELAWARE II, has its home port at Sandy Hook. The 156-foot, 483-ton ship has a cruising speed of 12 knots, endurance of 30 days, and range of 8,000 miles. The personnel capacity is 8 scientists and 15 officers and crew. There are 250 square feet of wet-laboratory floor space. Standard measurements and collections made on board the DELAWARE II include hydrographics, hydroacoustics, benthic invertebrates, plankton, and groundfish and associated species.

The Lionel A. Walford Library has 320 journals or other serials (bound in 6,900 volumes), 2,600 books, and 1,300 volumes of reprints. Maintained in the library are three special collections: Walford (fishery biology), Nelson Benedict (sport fishing), and Schaefer (marine biology). Major subjects of the full collection are marine fishery biology, biological oceanography, water pollution (sewage, dredge spoils, thermal, and chemical), and identification and taxonomy of fish.

MILFORD LABORATORY

The Milford Laboratory, located on Rogers Avenue in Milford, Connecticut, overlooks Milford Harbor. Nearby transportation includes the New Haven Airport, Bridgeport Airport (5 miles), Milford Bus Depot, Interstate 95, and Connecticut Routes 5 and 15 (Wilbur Cross and Merritt Parkways, respectively).

The 10-acre facility holds the Laboratory building, Laboratory annex building, and shop/pump house building.

Special research facilities include an extensive experimental tank farm with 60 fiberglass tanks (30x4x1½ feet). The tank farm permits the rearing, holding, and experimentation with a large variety and number of shellfish, particularly clams and oysters.

Two rooms devoted to algae production have a constant temperature of 13°C. The algae production serves not only to supply the experimental shellfish organisms on hand with an adequate source of food, but also permits research into the dietary requirements and food and feeding habits of those shellfish organisms.

A large exposure laboratory possesses a battery of all-glass 20-gallon aquaria and a battery of fiberglass 55-gallon tanks. Nine diluter systems supply constant levels of various pollutants into the aquaria and tanks. This system allows determinations of long-term effects of low levels of pollutants, acting both individually and in combinations, on various species, sizes, and ages of organisms.

Approximately 125 journals, 50 serial and nonserial special collections, and 30 miscellaneous catalogued items are bound in the library's 4,000 volumes. Major subjects are marine biology, microbiology, genetics, and chemistry. A special collection of reprints emphasizes marine bivalve mollusks.

OXFORD LABORATORY

The Oxford Laboratory is located on Railroad Avenue in Oxford, Maryland, and overlooks the Tred Avon River, a fertile estuary of Chesapeake Bay. Nearby transportation includes the bus depot and municipal airport in Easton (10 miles). The Easton Municipal Airport connects twice daily with Washington National Airport via Maryland Airlines.

The 11-acre compound includes six buildings (main laboratory building, animal experimentation house, a frame building, two storage buildings, and a shop/pump house).and three trailers. Two of the three trailers are owned by the Laboratory; the other is owned by the State of Maryland. A small wooden building has recently been converted to offices for the Environmental Assessment Branch of the Northeast Regional Office.

Special research facilities include four, ¼-acre earthen ponds for holding and rearing purposes, a dock for supporting oyster trays and strings, rafts for suspending oysters, a saltwater pumping system for the ponds and the laboratories, an electron microscope, and a ¼-acre evaporative water disposal lagoon.

The Laboratory's Library contains 7,000 bound volumes consisting of journals and texts and a collection of over 15,000 reprints. It currently receives over 300 serial publications, 200 of which are journal subscriptions. Fields of concentration are pathobiology of fish and other nonmammalian marine organisms, cell biology, marine biology, physiology, zoology, environmental quality, ecology, and commercial fisheries.

NATIONAL SYSTEMATICS LABORATORY

Housed in the U.S. National Museum of Natural History (USNM), the National Systematics Laboratory is situated on the corner of Tenth Street and Constitution Avenue, Northwest, in the heart of Washington, D.C. National Airport and Interstate 95 are within minutes of the facility. Union Station offers rail service within walking distance of the Laboratory. Access is available from the Smithsonian or Federal Triangle Metro Stations.

The National Systematics Laboratory occupies nine rooms, including laboratories, offices, and a processing room, within the USNM. There is access to such facilities of the USNM as the biological collections, libraries, and histology and x-ray laboratories.

The library collection includes 4,300 journals and over 195,000 volumes. Areas of concentration within the library are zoological and botanical systematics, paleobiology, mineral sciences, anthropology, invertebrate zoology, and vertebrate zoology.