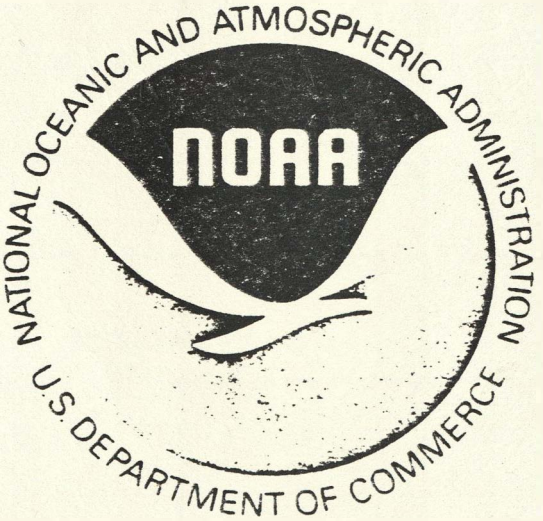
MARINE SCIENCE PROGRAMS AND ACTIVITIES

OF THE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

FISCAL YEARS 1982 - 1985



OCTOBER 1985

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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FYs 82 - 85

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FYs 1982 - 1985

Within the Department of Commerce, all marine science programs and activities are carried out by the five line organizations of the National Oceanic and Atmospheric Administration.

OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH

The marine science programs and activities of NOAA's office of Oceanic and Atmospheric Research (OAR) include: (1) the marine and Great Lakes investigations of the Environmental Research Laboratories; and (2) the NOAA Undersea Research Program. The National Sea Grant College Program is administratively a part of OAR; however, because of the size and scope of that program, it is treated in a separate section B.

A. Marine Research

The OAR, through two marine laboratories and one laboratory located in the Great Lakes region, conducts programs of fundamental research, and performs services to improve understanding and prediction of the marine environment. Major research areas include oceanic contributions to climate variability; marine environment assessment; marine services; and marine resources. Program objectives are to improve methods of prediction, and the transfer of information and technology to operational arms of the government and to the public.

Ocean Climate Research

OAR conducts observational and theoretical research to improve understanding of the relationship between ocean dynamics and large-scale air-sea interactions, especially as they contribute to global heat transport and interannual and longer-term climate variability. Studies of interannual climate variability have focused on the description, understanding and prediction of the large-scale physical processes associated with the El Nino/Southern Oscillation (ENSO) phenomenon.

This research is carried out by several countries participating in the Tropical Ocean Global Atmosphere (TOGA) program. TOGA is an observational program designed to document the life cycle of an ENSO event. The current effort is to compile and interpret observations of oceanic and atmospheric variables on time scales of a few days to a few weeks in order to predict climate anomalies and winter conditions a season or more in advance.

Investigation of the ocean's role in climate variability over longer periods is conducted primarily through the program Subtropical Atlantic Climate Studies (STACS), which develops techniques to monitor the ocean transport of solar heat from the subtropical regions northward.

During FY 1982 and 1983, STACS investigators conducted observations in the Florida Current with the dual purposes of obtaining a data base specifically pertinent to the heat transport problem, and of developing inexpensive technology to monitor the current over extended time periods. In FY 1984, potential monitoring methods were evaluated and identified. In FY 1985, STACS observations were extended into the Caribbean Sea and Windward Passage to determine the magnitude of Florida Current transport and variability.

OAR also conducts research on the role of the oceans in the global carbon cycle, which is very relevant to predicting the effects of CO_2 buildup on long-term climate. Last year NOAA investigators carried out chemical observations in the North Pacific Ocean as part of a program to investigate the ocean's capacity to assimilate CO_2. OAR also conducts theoretical atmosphere-ocean studies to evaluate the long-term climatic impacts of atmospheric CO_2 buildup. In FY 1983 and 1984 the transient response of climate to an increase of atmospheric CO_2 was investigated by means of a coupled ocean-atmosphere general circulation model using different CO_2 concentrations. Related modeling studies investigated the response time of atmospheric CO_2 concentrations to changes in ocean circulation, thus providing new insights on feedback mechanisms in the ocean-atmosphere carbon cycle.

Marine Assessment Research

OAR conducts research to improve understanding and prediction of natural marine systems and their responses to human-induced stresses, and to develop improved environmental prediction models and advisory services necessary for marine assessment. Scientific information is developed and transferred to support decisions pertinent to marine pollution, development and use of marine resources, and other activities affecting marine ecosystems and human health. Research topics include transport and cycling of pollutants in estuaries and coastal waters; sedimentary processes and interaction of sediments with pollutants; ecosystem and nutrient dynamics; and circulation and mixing processes.

In FY 1983 OAR scientists developed a model of pollutant recirculation in deep, stratified estuaries and coastal embayments. In FY 1984 the model was applied to Puget Sound and demonstrated that recirculation leads to the

dispersal and retention of long-lived pollutants throughout the estuary with magnified concentrations. Efforts continue in FY 1985 to obtain additional model verification.

Most contaminants of concern in coastal and estuarine and Great Lakes waters have a high affinity for particulates, which settle out to become sediments. In FY 1983 a demographic/pollutant-source model of the Puget Sound watershed was developed that related changing population, transportation, industries, and fuel types to measured concentrations of contaminants in sediment cores in the Sound. Efforts in FY 1984 and 1985 focused on refining the model so that it can be used to assist in predicting future pollutant levels to be expected from further development and technological change.

Research on pollutant-sediment interactions conducted in the Gulf of Mexico during FY 1983 determined that the 1982 Mississippi River burden of lead and cadmium has decreased by 20% and 50%, respectively, relative to 1975 values. These reduced concentrations are believed to be attributable to the reduction in use of leaded gasoline and tighter controls on industrial discharges. This research also demonstrated that most of the lead and cadmium is attached to particles, which settle to the bottom and thus remove pollutants from the water column.

As part of a program examining various aspects of nutrient cycling and ecosystem response, OAR and NMFS conducted joint field studies in the Gulf of Mexico during FY 1982 and 1983 to determine the extent to which dissolved organic matter bind bioactive metals, and thus modulate their toxic effects on the food web.

OAR researchers in the Great Lakes completed a pilot study in FY 1983 of the role of benthic (bottom-dwelling) invertebrates in the regeneration of phosphorus, the most important nutrient contributing to eutrophication of the

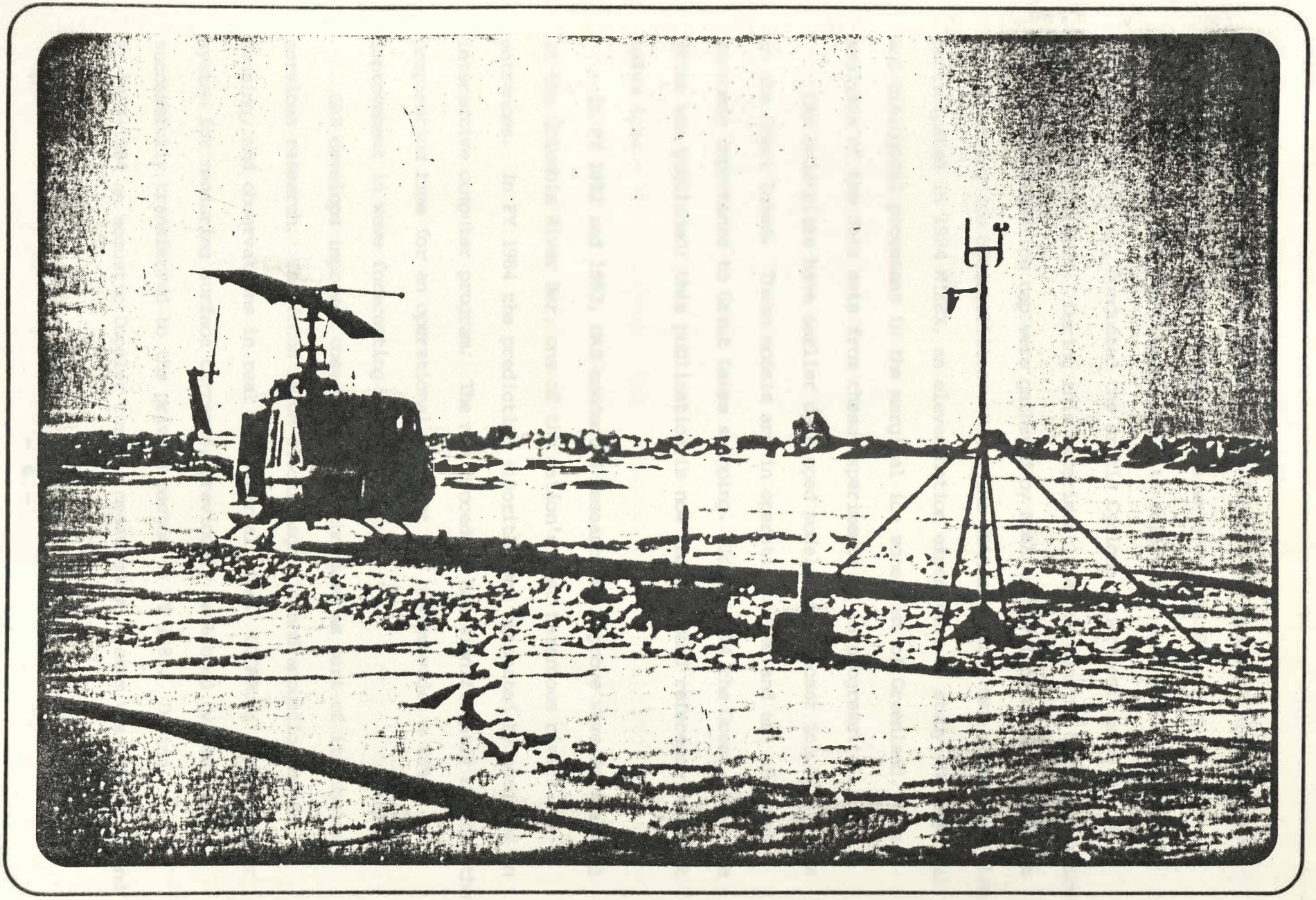
lakes. Results indicated that these invertebrates may be as important as bacteria in the mineralization of phosphorus in sediments. The results of this research are being used to improve models of nutrient cycling.

The ocean is both a sink and a source for chemicals found in the atmosphere. NOAA's research addresses the ocean-atmosphere exchange in order to better understand the global chemistry budget. With regard to acid precipitation, for example, NOAA researchers are trying to determine the role of the ocean as a natural source of acid rain precursors. Activities in FY 1982 and 1983 concentrated on evaluating the importance of organic sulfur compounds produced by marine plankton. These compounds diffuse from the surface waters into the atmosphere. Research in FY 1984 documented the oceanic contribution to precursors of atmospheric formic acid, a significant contributor to the acidity of rain in remote regions. Both activities are continuing in FY 1985.

Marine Services Research

OAR conducts research to improve understanding and the capability to predict phenomena important to marine warning and forecasting. Topics of study include coastal currents, winds, waves, storm surges and seiches, sea and lake ice, and tsunami. Research stresses development of improved prediction models and observational techniques, especially remote sensing.

Another research objective is to develop techniques to forecast sea ice conditions 5 to 6 days in advance for aiding fisheries and navigation in ice-covered regions. In FY 1983 OAR, in cooperation with the Office of Naval Research, NASA, and other NOAA elements, completed a study of sea ice drift and ice edge behavior in the Bering Sea. In FY 1984 a forecasting model was developed for sea ice extent in the Bering Sea and was operationally tested by



NOAA is conducting studies of sea ice drift with the assistance of remote sensing data, such as that provided by these satellite transmitters deployed in Bering Sea ice.

the National Weather Service during the 1983-84 ice season. Plans are to extend this research into the more formidable Chukchi Sea.

In FY 1984, OAR, in cooperation with scientists from NASA, U.S. Navy, Iceland, and Norway, conducted the Arctic Cyclone Experiment using the NOAA and NASA P-3 aircraft. During this experiment, remote sensing data of sea ice and the Greenland ice cap were gathered by NOAA to develop better techniques for observing ice by satellites. Using the NOAA aircraft, OAR scientists also participated in 1984 MIZEX, an eleven-nation experiment to study the physical and biological processes in the marginal ice zone east of Greenland. The analysis of the data sets from these experiments is in progress.

OAR scientists have earlier developed models to forecast ice conditions in the Great Lakes. These models are in operational use and are of great economic importance to Great Lakes shipping. In FY 1984 the Great Lakes Ice Atlas was published; this publication is now the standard reference on Great Lakes ice.

In FY 1982 and 1983, OAR conducted research to improve wave forecasting at the Columbia River Bar, one of the nation's most hazardous river entrances. In FY 1984 the prediction algorithm was automated by means of an interactive computer program. The new procedure has significantly reduced the preparation time for an operational forecast and has provided a 25% improvement in wave forecasting capability.

OAR develops improved observational techniques as part of its marine services research. The focus is on electromagnetic and acoustic remote sensing, and observations in real or near-real time. CODAR, a Doppler radar system for measuring surface currents, previously developed by OAR, was successfully transferred to the private sector in FY 1983. During FY 1982-1984 an acoustic Doppler current measurement system was developed and

tested. In FY 1985 this system is being used at the Port of Miami in a pilot study to provide real-time current information to ship operators who can use it to plot more energy-efficient courses.

Marine Resources Research

In FY 1982 OAR scientists organized and directed an interdisciplinary NATO Advanced Research Institute on the subject of "Hydrothermal Processes at Seafloor Spreading Centers", which brought together scientific leaders from 15 nations. OAR scientists also participated in a multi-institutional research project to carry out a field study of hydrothermal processes on the Trans-Atlantic Geothermal (TAG) field on the Mid-Atlantic Ridge.

In FY 1984 the VENTS program was implemented, representing a major expansion of OAR's research on hydrothermal processes at seafloor spreading centers. OAR scientists conducted major multidisciplinary cruises to both the Atlantic and Pacific Oceans. The Pacific cruise, which included operational dives by the submersible ALVIN, was conducted at selected sites along the entire Gorda-Juan de Fuca Ridge system. Research cruises to this area are continuing in FY 1985.

In FY 1985 OAR and NMFS initiated a joint program known as Fisheries Oceanography Coordinated Investigations (FOCI), to acquire the information necessary to understand and predict the effects of environmental variability on the abundance and variability of fish in major U.S. fisheries. The FOCI program will investigate the most important U.S. fisheries with initial attention to the walleye pollock in Alaska. Information from FOCI on the productivity and associated ecosystems interactions of this target species could lead to more efficient management of the fishery.

In preparation for FOCI, the Fisheries Oceanography Experiment (FOX) was initiated in FY 1985. This is a multidisciplinary effort conducted in the Shelikof Strait, Alaska on a large spawning mass of pollock recently discovered.

Undersea Research

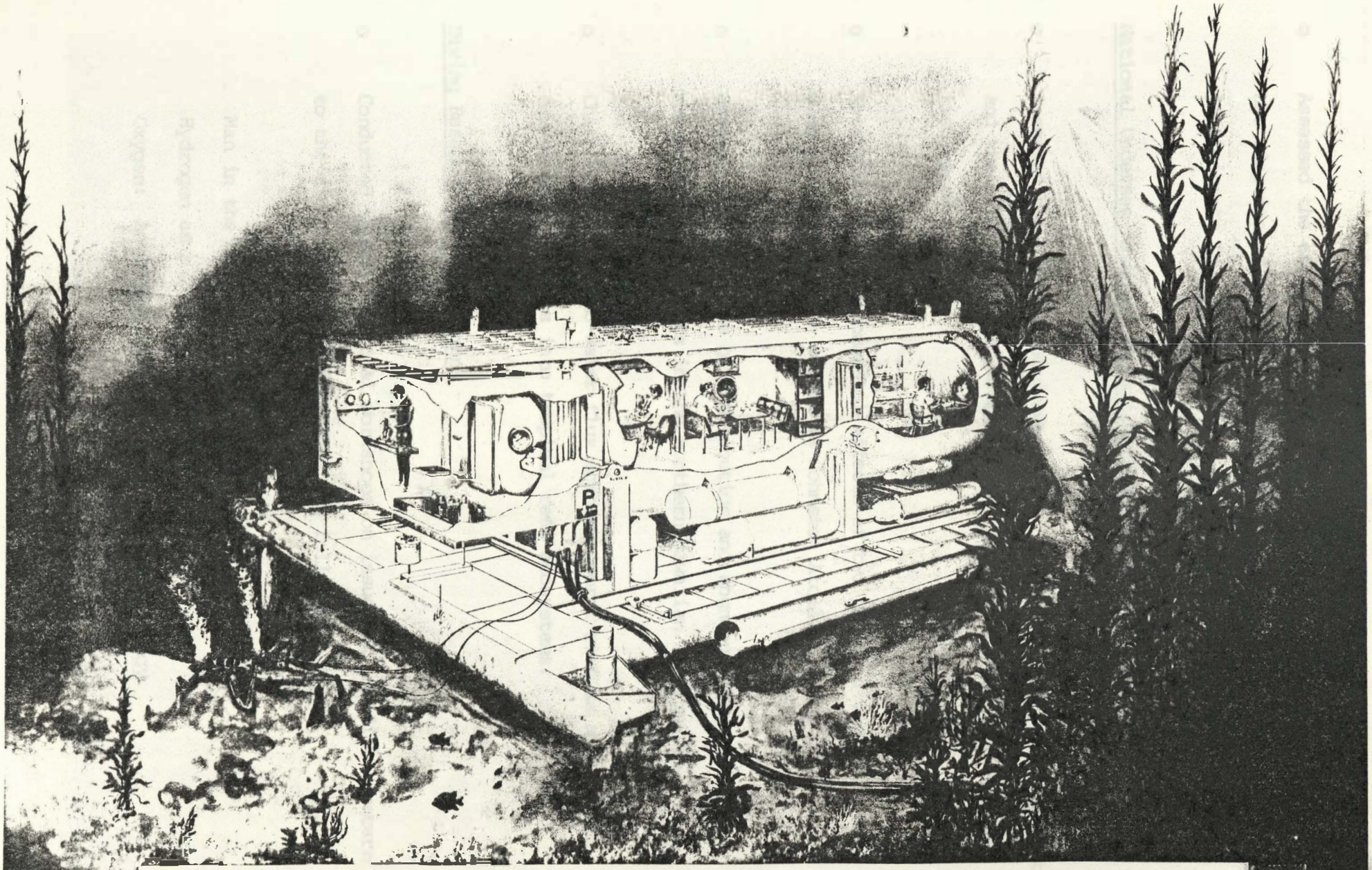
OAR's Undersea Research Program primarily is composed of five major program activities: shallow-water and deep-water submersible research, national undersea research program facilities, diving research and development, and cooperative international activities. Highlights of major accomplishments for each of these program activities during 1982-1985 are provided below:

Deep-Water Submersible Research

- Recorded the first direct observations of an active hydrothermal field on a slow-spreading oceanic ridge.

Shallow-Water Submersible Research

- Characterized the biological and geological properties of 12 major submarine canyons on the New England outer continental shelf which led to the designation of these canyons as environmentally sensitive areas and consequently, these areas were omitted from oil and gas exploration activities.



Artist's conception of NOAA's newest habitat, the George F. Bond, a manned saturation habitat allowing 6 scientists to remain on the seafloor at maximum depth of 120 feet for up to 30 days. Scheduled for completion in early 1986.

- o Assessed the efficiency of halibut longline gear which has led to the adoption of modified harvesting gear by virtually all the participants in this fishery.

National Undersea Research Facilities Program

o Assessed the disposal of dredge spoil along the northeast U.S. coast and the effects of such disposal on commercially important benthic fish resources.

o Determined the environmental effects of two proposed chemical waste disposal sites on the slopes of Johnston Atoll.

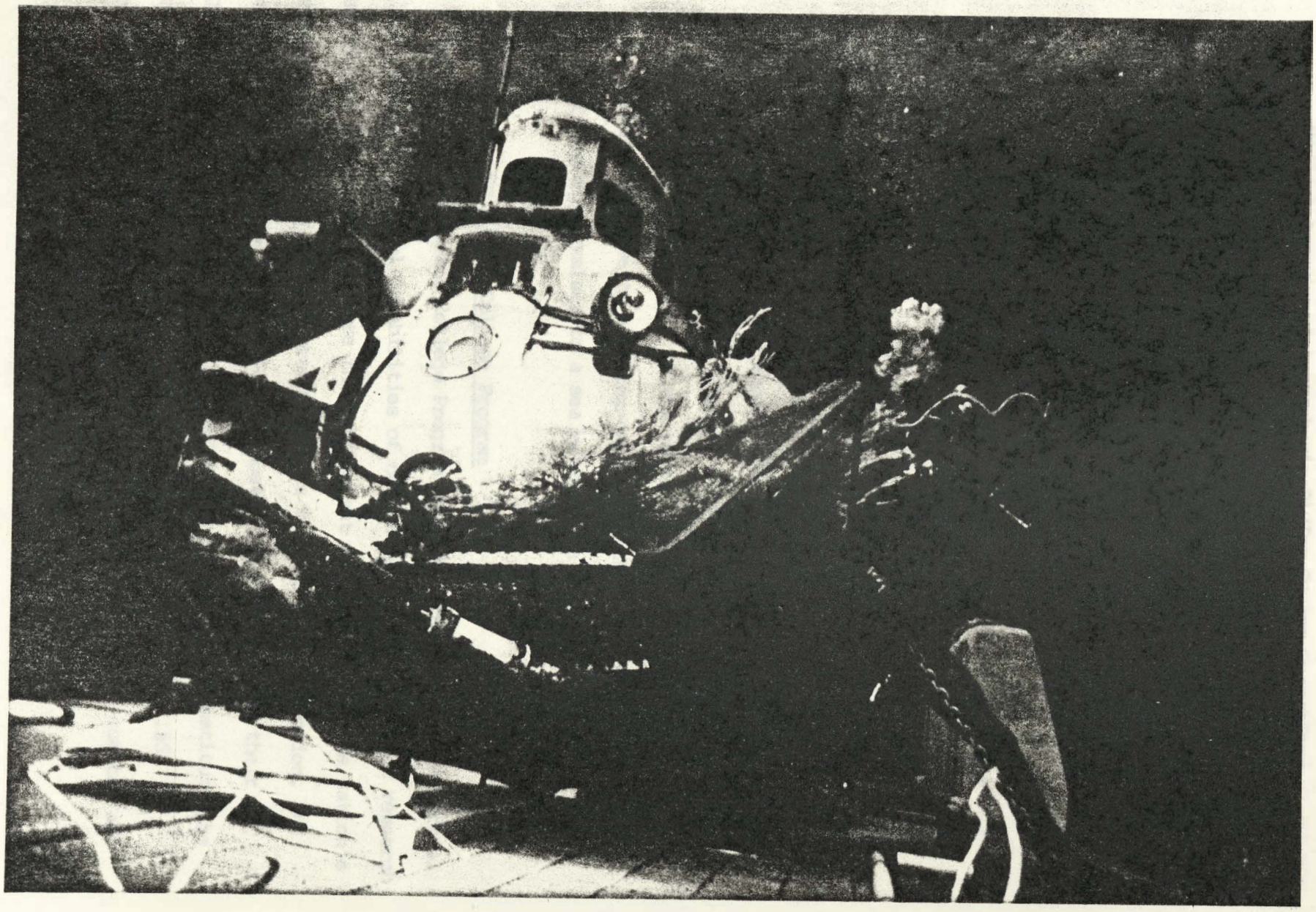
o Assessed the patterns of distribution and abundance of cobalt-rich manganese oxide crusts in the northern Hawaiian Archipelago.

o Characterized ground-water flux across a coral reef as a potential source of pollutants into tropical reef ecosystems.

Diving Research and Development

o Conducted several national workshops on issues of immediate concern to the diving community including the following:

Man in the Cold Environment
Hydrogen as a Diving Gas
Oxygen: An In-Depth Study of its Pathophysiology



Makalii, a 2-man submersible in NOAA's Undersea Research Program at the University of Hawaii, returning from a deepsea mission loaded with samples and being locked on to its Launch Retrieval and Transport Barge for returning to the sea surface.

Medical Aspects of Atmospheric Diving System Operations

Safe Diving Procedures for Excursions from Saturation Diving

- o Established the Diving Accident Network to provide 24-hour medical consultation for diving accident victims anywhere in the United States.

- o Developed new mixed gas diving methods including tables for decompression and vertical excursions.

Cooperative International Activities

- o Conducted a joint U.S.-Japan experimental deep-water dive, Sea Dragon VI, in Yokosuka, Japan. This experiment permitted comprehensive studies on the physiological functions of divers during exposure to a helium-oxygen breathing gas environment at a pressure equivalent to a sea water depth of 1000 feet.

B. The National Sea Grant College Program

The National Sea Grant College Program (NSGCP) marshals the intellectual talents and institutional capabilities of our universities and marine research institutions in order to promote the development and wise use of the nation's marine resources. The program provides funds for research, education, and advisory/extension services based upon competitive proposals and their rigorous review. Thirty Sea Grant colleges and institutions constitute the core of the NSGCP, which operates through a national network of 135 participating university and marine research institutions in 29 coastal and

Great Lakes States, the District of Columbia, Puerto Rico, and Guam.

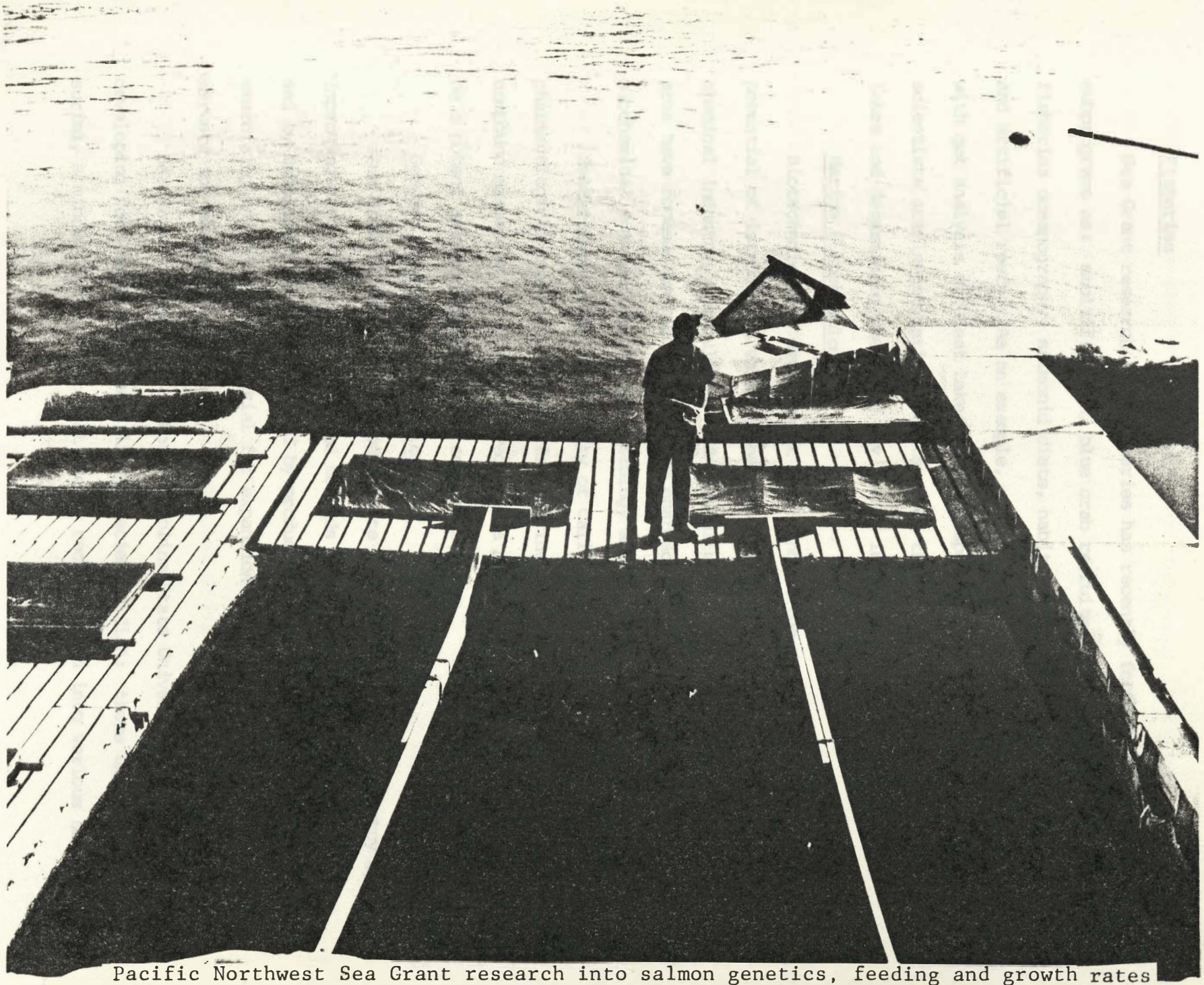
During any fiscal year, the National Sea Grant College Program involves the participation of over 3,000 scientists, engineers, economists, lawyers, educators, advisory agents, and others working together on common problems.

Sea Grant supports projects in a wide array of marine-related subjects through its five divisions: Living Resources, Non-Living Resources, Technology and Commercial Development, Environmental Studies, and Human Resources. The following presents selected accomplishments during FYs 82-85.

Living Resources

Aquaculture

Sea Grant has a lead role in the development of aquaculture for marine, estuarine and Great Lakes species as mandated by the National Aquaculture Act of 1980. During FY 1984 more attention was devoted to studies of hard clams and scallops; salmon studies have been numerous in prior years and promising research results have been obtained. The coho salmon is the first instance of a truly domesticated aquatic species. Such salmon have been raised in net pens in Puget Sound, and Sea Grant research into salmon genetics, feeding, and improved growth rates at the University of Washington has aided this development. Several companies in the Pacific Northwest have gone into commercial production using a net-pen fishery for coho salmon.



Pacific Northwest Sea Grant research into salmon genetics, feeding and growth rates has contributed greatly to the development of raising coho salmon in net-pens for commercial production.

Fisheries

Sea Grant research into fisheries has recently focused on such subprograms as: smoltification, blue crab recruitment, stock separation, fisheries oceanography, salmonid diets, habitat fish production relationships, and artificial reefs. As an example, research on salmon diets is concerned with gut analysis of Great Lakes salmonid species. Through such analysis, scientists are investigating the status of the forage base in each of the lakes and determining where and why shifts in diets occur.

Marine Biotechnology

Biotechnological development of living marine resources has the potential of introducing valuable new products and services to medicine, the chemical industry, agriculture, and aquaculture. Sea Grant projects in this area have focused on biochemistry and pharmacology, genetic engineering, biochemical engineering, and microbiology and botany.

Researchers at the University of California have been testing new pharmacological compounds derived from marine organisms. For example, the compound manoalide, which is derived from a marine sponge, has been shown to be a potent anti-inflammatory and analgesic agent.

Seafood Science and Technology

Sea Grant's research in food science assists the fishing industry by improving processing technology and methods for assuring safety of seafood, and by developing new products and by-products. This research is relevant to exercising the enormous potential for expansion of domestic and foreign markets for seafood.

Sea Grant researchers at North Carolina State University have been developing food uses for underutilized species of fish; these uses involve surimi, a minced fish product that can be reconstituted into various seafood

products. The researchers have worked out the details of the texture, chemical structure, binders and waste reduction for surimi. Atlantic and Gulf menhaden, the nation's largest fishery in terms of volume but rather low in value per pound, is currently being evaluated as a possible candidate for use in surimi, with one scientist predicting that menhaden may become "the soybean of the sea."

Non-Living Resources

Coastal Processes

Recent Sea Grant projects in coastal processes, which study both oceanic forcing processes (e.g., waves, currents, and tides) and resulting changes of the coast and seafloor, have focused primarily on motion and transport studies. The Nearshore Sediment Transport Study, a coordinated multi-institutional Sea Grant national project, should increase understanding of the physics of water-sediment interaction in the coastal zone. Field data collection was completed during FY 1982 and all data sent to NOAA's National Oceanographic Data Center. Analysis of these data and preparation of a concluding report took place the following year, with publication scheduled for 1985.

Energy

Sea Grant energy-related projects have dealt with issues such as energy extraction and conservation. A project being coordinated by the University of California at Berkeley is developing a rational methodology for the design of a safe offshore oil production platform. Emphasis is on assessing those phenomena that will affect future development of the petroleum resources of the southern Beaufort Sea, off the North Slope of Alaska. The production areas lie in deep water and are subject to extreme, dynamic sea ice forces in both winter and summer.

Marine Geological Resources

Marine geological research supported by Sea Grant is directed toward increasing basic knowledge of seabed minerals and developing the technology for both recovery and use of those resources. Commodity groups receiving attention include: sand, gravel and shell; manganese nodules; phosphorite rock and polymetallic sulfides; heavy mineral placers; petroleum; and ground water.

Mississippi/Alabama Sea Grant geologists have discovered promising accumulations of ilmenite, the source of titanium, and other minerals on the floor of the Gulf of Mexico, south of the barrier islands of the two states. Titanium is the mineral now replacing lead, banned in consumer paints and paint pigments since 1977. Manufacturing plants in the South that use the mineral to produce titanium dioxide currently import their raw material from Australia. The initial survey, conducted in cooperation with Georgia Sea Grant researchers who provided sophisticated remote sensing equipment, also found marketable bulk-type materials such as glass and foundry sand plus three high-grade refractories used in ceramics.

Diving Physiology and Safety

Understanding the fundamental requirements for increasing man's capacity both to perform underwater scientific research and to enjoy the water on a recreational basis is the focus of Sea Grant's efforts in diving physiology and safety. Mortality is a problem in both commercial and military operations and for recreational divers. Approximately 140 sport SCUBA deaths occur each year in the United States.

University of Wisconsin Sea Grant scientists, through animal experiments and a survey of diving accidents, have found that the nation's 1.5 million scuba divers face a greater risk of paralysis and death from decompression

sickness than was once believed. The scientists found an unexpectedly high incidence of spinal cord injuries caused by the deep, short-duration dives that scuba divers often make. From their experiments, they stress that divers stay well within the diving decompression guidelines that govern the depth and duration of a safe dive. They also advise that scuba-diving vacationers rest a day before driving over the mountains or flying to get home.

Technology and Commercial Development

Marine and Coastal Transportation Systems

Sea Grant marine and coastal transportation systems projects have focused on the efficient management of American ports in the face of rapid technological and social change. A research agenda for this subject area was carefully developed at a recent workshop held by the University of Southern California. Research priorities developed at this workshop include topics such as international trade and seaport demand, regional seaport planning, and seaport finance in the areas of debts, fees, and surpluses.

Marine Economics

Research in marine economics contributes valuable information about the economic processes at work in delivering a wide mix of goods and services to the world marketplace. Sea Grant-funded projects in this area encompass such fields as fisheries management and development, marine recreation, coastal zone resources, marine minerals, and transportation.

A research project on fish markets is now being conducted in Maine. The City of Portland has constructed a new fish pier and will establish a fish auction as part of this development. Maine fishermen have traditionally marketed their catch through direct sales to processors and wholesalers, with prices based on New Bedford or Boston markets. The Portland auction will be an advance in two major respects. First, buyers and sellers will have better

information available to them, in the form of alternative offers and bids. And second, the auction will be designed so that the market should register price premiums for high quality fish, and lead to the improvement in the quality of fish and shellfish landed.

Ocean Engineering

Sea Grant support for ocean engineering projects encompasses a variety of subprograms including: ship design, construction and safety; remote sensing; offshore structure design and analysis; oil spills; and acoustics. In the acoustics subprogram, for example, four projects are currently being supported.

The University of Washington is studying acoustics as a tool for fisheries resource assessment; the University of Florida is exploring the use of acoustics as a nondestructive testing tool for inspection of structures; Oregon State University is investigating acoustic control of marine mammals; and Southern Illinois University is evaluating location devices for divers.

Marine Recreation and Tourism

Recreation and tourism have been cited as the fastest growing industry in the United States, and Sea Grant's program in recreation and tourism research recognizes the importance of this sector of the economy. A regional research initiative begun in FY 1984 involves Sea Grant programs in Connecticut, New York, Massachusetts, New Hampshire, and Rhode Island. Case studies of tourism development undertaken by local communities in the Northeast will be used to develop a general model for determining the relative advantages and disadvantages of coastal tourism. The research will develop an analytical method to project benefits and impacts from future investments in tourism.

Environmental Studies

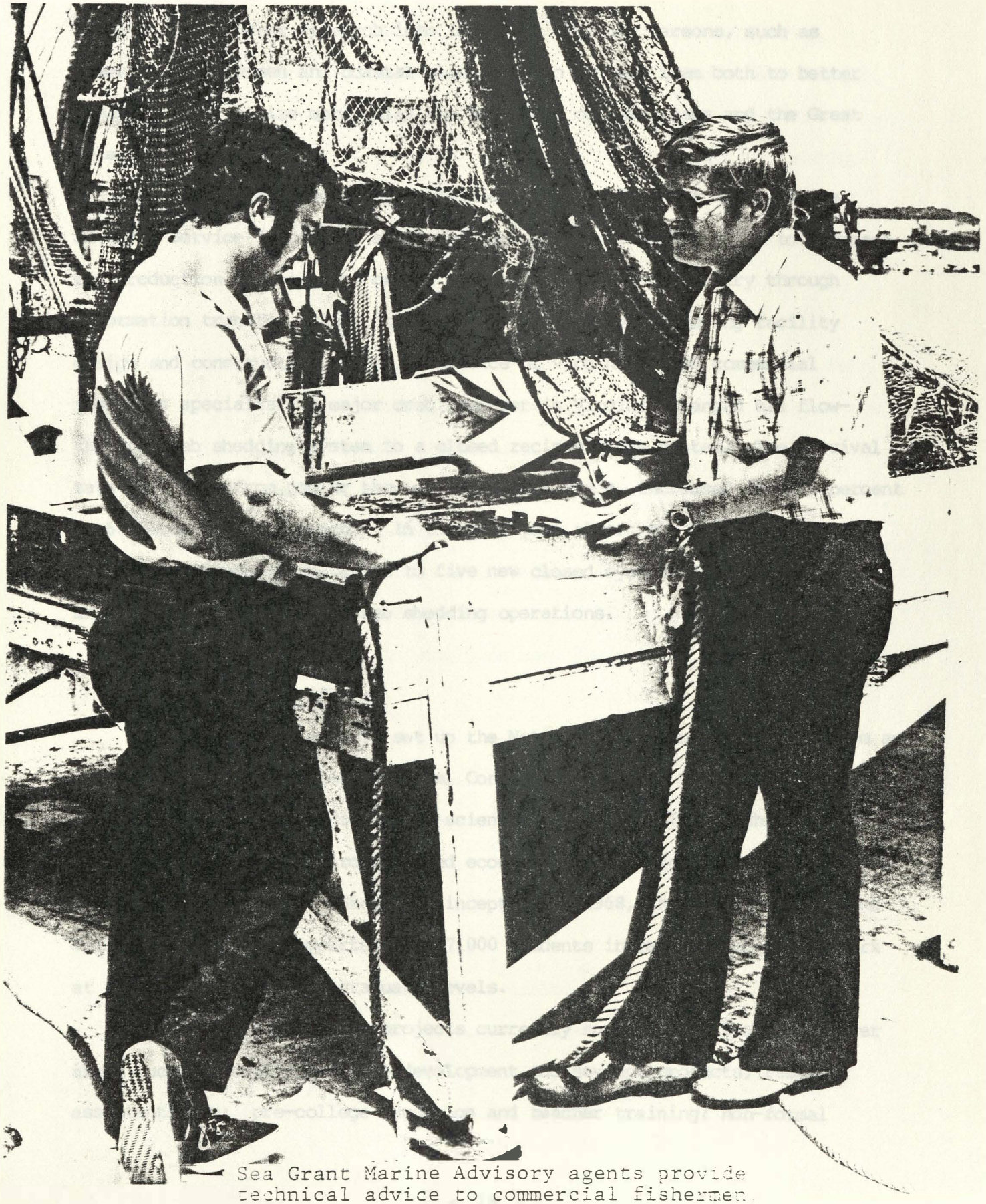
Sea Grant projects in environmental studies examine the major problems and management issues affecting our coastal ecosystems. The primary goal of these projects is to develop knowledge that will permit multiple use of the environment consistent with the maintenance of strong and healthy natural ecosystems.

A two-year multidisciplinary study, conducted jointly by the Delaware and the New Jersey Sea Grant Programs and cosponsored by the Delaware River and Bay Authority, has found that the health of the Delaware Bay and River, despite heavy use of the estuary, is on the upswing. Potential for expanding marine activities in the area is now evident. Research results showed that: the Delaware flushes itself every 80 days; sediments contain trace metals in some areas and problems could develop but there are now no toxic concentrations; chlorine discharges from power plants dissipate quickly and don't form compounds (but they should be watched); and predominant fisheries can continue at present levels, and some even increase, without harm.

Human Resources

Marine Advisory Service

The National Sea Grant Marine Advisory Service (MAS) program is designed to improve the productivity of marine resources and the quality of life for the people who enjoy them, are affected by them, or who depend on them for a living. A network of about 300 agents and specialists, who are affiliated with Sea Grant universities and work in the field, provide an essential link between the people who live and work in coastal areas and researchers at the universities. These agents and specialists are experts in areas such as seafood technology, marine economics, coastal engineering, commercial fishing, recreation, and communications. Through workshops, seminars, publications, radio, television, demonstrations and person-to-person contact, they put the



Sea Grant Marine Advisory agents provide technical advice to commercial fishermen.

results of Sea Grant research into the hands of those persons, such as commercial fishermen and coastal planners, who can use them both to better manage and to realize more fully the potential of the oceans and the Great Lakes.

As an example of advisory activities, the Virginia Sea Grant Marine Advisory Service initiated, at the request of industry, a program to increase the production capabilities of the soft shell blue crab industry through information transfer, diagnostic services and improved shedding facility design and construction. Upon the advice of Virginia's MAS commercial fisheries specialist, a major crab producer in Virginia changed his flow-through crab shedding system to a closed recirculating system. The survival rate on crabs, from peeler through soft shell stage, increased from 35 percent to 65 percent in one season. In the past year alone, the MAS specialist has provided in-depth consultation to five new closed system crab shedding firms and to over 30 individual crab shedding operations.

Education and Training

In the legislation that set up the National Sea Grant College Program as a cooperative federal-state program, Congress encouraged the universities to develop a skilled labor force - of scientists, engineers and technicians - that can benefit our environment and economy, and transfer knowledge from the university to industry. Since its inception in 1968, the National Sea Grant College Program has supported over 7,000 students in research or course work at the undergraduate and graduate levels.

Education and training projects currently supported by Sea Grant cover areas such as: college course development and student projects; research assistantships; pre-college education and teacher training; non-formal

education; technical and vocational training; the Sea Grant Fellowship Program; and Sea Grant interns. Non-formal education projects, for example, include marine and aquatic education efforts that typically take place at science centers, museums, and aquaria, while the the Sea Grant Fellowship Program provides educational assistance to qualified groups of students of ocean and coastal resources who have been underrepresented in marine fields.

Marine Policy and Social Sciences

Sea Grant projects in marine policy and social sciences research help direct beneficial growth, revise policies to improve efficiency, suggest new institutional arrangements, and provide data bases for evaluating the impacts of change. Social science research at the University of Washington, for instance, has helped develop a more flexible waterfront plan for the Seattle harbor. Options for management of Great Lakes water are the focus of a current project at the University of Wisconsin. All these projects are interdisciplinary in nature, drawing upon many fields to help solve marine problems.

Ocean and Coastal Law

Ocean and coastal law issues are studied in continuing programs of research at designated universities and through individual projects supported by Sea Grant. While some programs are broad-based in nature, others focus on particular areas of the law such as the Lewis and Clark College of Law, which specializes in anadromous fish problems in the Pacific Northwest. Recent individual, non-continuing projects have included a University of Florida study of legal problems in post-hurricane reconstruction and a University of California project to evaluate the effects of fisheries laws in California between 1945-1970.

The marine science programs and activities of the National Marine Fisheries Service (NMFS) include: (1) fish and shellfish research and assessment; (2) environmental research; (3) product quality and safety research; and (4) research in support of NOAA's responsibilities under the Marine Mammal Protection Act and the Endangered Species Act.

Fish and Shellfish Research and Assessment

In the FY 82-84 period, the Northeast Fisheries Center in Woods Hole, Massachusetts, conducted ten large-scale surveys of fish eggs and larvae in the Northwest Atlantic to evaluate recruitment and to provide fishery-independent estimates of spawning populations for major commercial and recreational species and their principal fish prey. Special emphasis in 1984 was on spring and summer sampling to provide a basis for estimating the population of bluefish spawning north of Cape Hatteras. Surveys in other seasons showed that the sand lance (a major prey for many fish-eating fish species, as well as birds and mammals) are near record high levels for the eighth consecutive year, whereas the once productive spawning beds of Atlantic herring on Georges Bank were again essentially barren. However, a few larvae were caught on the eastern part of Georges Bank in 1985, the first seen in six years.

New emphasis was placed on the role of predators in food web studies to document the magnitude of predation on young fish, and to provide both a better understanding of predator-prey interaction in general and a basis for management of multispecies fisheries. Reports on diet and consumption by several major fish predators, including bluefish, spiny dogfish, squid and large pelagics (swordfish and sandbar shark) were issued.

Zooplankton studies in the Northwest Atlantic over the past 70 years have not shown the large-scale changes in abundance or species composition found in the Northeast Atlantic and the North Sea. Recent declines in fish populations off our coasts appear related more to excessive fishing pressure than to any changes in abundance of zooplankton.

Area and time distribution patterns of larval fishes were analyzed in relation to circulation, phytoplankton production, and changes in abundance of zooplankton in continental shelf waters between Cape Hatteras and Cape Sable, Nova Scotia. Spawning strategies were related to topographic features and circulation patterns, which in turn play a key role in maintenance of the stocks. Peak spawning for several important species was shown to be directly related to increasing abundance levels of their prey (copepods). Other species have developed a level spawning strategy, producing eggs and larvae over a protracted time period in the entire shelf area, allowing these populations to increase rapidly in response to favorable conditions.

A computerized system was developed to automate the analysis of zooplankton samples. With this system, a 500-organism sample can be analyzed, including identification and measurement of all zooplankton, in 15-20 minutes. This is approximately one-tenth the time required for manual analysis.

The Northwest and Alaska Fisheries Center in Seattle conducted a triennial bottom trawl survey between Monterey Bay, California and Vancouver Island, British Columbia during July-October 1983. Over 2,000 sablefish (primarily juveniles) were tagged to study migratory behavior and recruitment patterns. Detailed results of the bottom trawl survey are available and a report examining population trends based on 1977, 1980, and 1983 surveys is in progress. The Center also conducted its annual surveys in the Gulf of Alaska, the eastern Bering Sea and the Aleutian Island chain.

At the Southeast Fisheries Center in Miami, Florida work continued on the Southeast Area Monitoring and Assessment Program (SEAMAP). This is a cooperative program between NMFS, the states and the Gulf States Marine Fisheries Commission. These research cruises focus on South Atlantic and Gulf menhaden and shrimp, Gulf bottomfish and such underutilized species as mackerels, squid, and butterfish.

The Southwest Fisheries Center in La Jolla, California, continued its study of global tuna resources. Research cruises were conducted to determine the abundance and distribution of anchovies and sardines in the California current system and rock fishes along the California coast. In addition, during the period, surveys were conducted of seamount resources in the Trust Territories of the Central Pacific and the marine resources of the Northwest Hawaiian Island chain.

The above are only some examples of the types of information that the NMFS collects for the benefit of the Regional Management Councils, the fishermen, the Congress, and the public.

Environmental Research

The NMFS is conducting the benthic surveillance portion of the National Status and Trends Program. This consists of collecting bottomfish and sediment samples at selected locations from Maine to Alaska, and analyzing them for a wide variety of hydrocarbons, chlorinated compounds, and heavy metals. Histopathological examinations of fish are conducted to ascertain the presence of lesions or tumors.

The field study procedures developed in the Puget Sound work are being used by NMFS in the National Benthic Surveillance Project to determine the extent and significance of pollution in Puget Sound and adjacent waters and to

evaluate the health of marine species in U.S. coastal waters.

NMFS scientists studied the influence of excessive freshwater inflow into a south Florida estuarine system. Sampling during the rainy season showed that, while the fish species composition in the estuary receiving excessive freshwater was similar to that in adjacent unaffected areas, the total number of individuals was severely depressed. Areas of potential low-oxygen (hypoxic) bottom water conditions were identified from satellite chlorophyll and temperature data. Research vessel sampling found no hypoxia along the entire Florida coast until the vessel approached the affected estuary.

Research continued in the northern Gulf of Mexico on the effects of trace metals on larval fish survival and growth and the accumulation and on detoxification of metal by fishery organisms.

NMFS scientists are studying the effects of logging operations on other renewable resources in Alaska, which continues to be of major concern to state resource managers. Two studies were conducted in 1984 to determine: (1) the effect of variable depths of bark deposited at log dumps on dungeness crabs and clams, and (2) the effects of logging on the winter distribution and mortality of coho salmon.

In the Northeast, NMFS scientists examined surf clams and hard clams to see if density of organisms, size of individuals, and the presence of predators affects growth. Studies of Atlantic mackerel eggs collected from the New York Bight showed egg mortality associated with aromatic hydrocarbons and PCBs. Slower development rates were associated with higher PCB and aromatic hydrocarbon levels. Embryo malformation was associated positively with high heavy metal levels. In a cooperative study with the U.S. Fish and Wildlife Service, the relationships of newly discovered strains of marine fish viruses and their virulence to juvenile fishes were clarified. In laboratory

studies of metal-exposed sea scallops, strong evidence was found that excessive amounts of copper produced highly toxic effects on the reproductive systems and even lethal effects in the kidneys. Overloads of cadmium, on the other hand, were found to be almost entirely concentrated in the kidney, and produce little observable effects on the scallop, other than to stimulate an earlier-than-normal development of eggs and sperm. A study of softshell clams, in cooperation with the Maryland Department of Natural Resources, resulted in the discovery of tumors in Chesapeake Bay clams. The progression and fatal nature of tumors in soft clams were demonstrated for the first time.

Large hydroelectric dams constructed on the mainstem and extensive dredging activities and industrial development within the estuary have substantially altered the environment of the Columbia-Snake River system and impaired important runs of anadromous fish. NMFS investigators conducted research to improve the system designed to transport juvenile and adult salmonids around or over upriver dams. The focus is on isolating and eliminating stress. This transportation program was a significant reason for an all-time record return of adult steelhead to the Columbia River in 1984. Additionally, NMFS scientists evaluated potential dredge spoil disposal sites along the Oregon coast.

Product Quality and Safety Research

NMFS researchers, in the southeast, compiled technical information to be used by industry during 1985 to petition the Food and Drug Administration for the human food use of partially hydrogenated menhaden oil. Information was gained on the composition and stability of menhaden lipids and how to prepare surimi from menhaden, a minced fish intermediate product used in making structured seafood products.

The NMFS scientists made progress in identifying the factors that influence the toxicity to humans of cadmium in oysters, a high priority for public health agencies.

A technology transfer forum was held to advise state public health agencies on how to apply a method of monitoring viruses in shellfish.

NMFS field units also participated in studies on the safety of smoked fish and fish packed in a vacuum and in modified atmospheres. Scientists demonstrated inhibition of C botulinum types A and E toxin production by liquid smoke and salt in hot-processed, smoke-flavored fish.

Protected Species

The Marine Mammal Protection Act of 1972 (MMPA) and the Endangered Species Act of 1973 (ESA) provide protection for many marine species. Under the MMPA, NMFS is responsible for seals, seal lions, dolphins, porpoises, and whales. Under the ESA, NMFS is responsible for eight species of whales, six species of sea turtles, one of porpoise, three of seal, and two species of fish.

The MMPA, with few exceptions, bans the taking or importing of marine mammals or their products into the United States. It has been a key factor in the recovery of several marine mammal populations. NMFS has dedicated significant resources to the study of marine mammal populations, life cycles, and reproductive capacities. Research in support of current and anticipated management decisions is a major portion of NMFS's marine mammal work.

Marine Mammal Protection Act

The MMPA Act allows permits to be issued for taking or importing marine mammals for scientific research and public display. NMFS monitors more than

NOAA administers the Marine Mammal Protection Act of 1972 with respect to whales, porpoises, seals, and seal lions. These northern fur seals on the Pribilof Islands are part of a dramatic conservation effort by the agency.

300 such permits for marine mammals. NMFS also issues permits allowing the unavoidable taking of marine mammals by domestic and foreign fishermen during commercial fishing operations. General permits are issued to foreign fishing associations of nations whose governments have agreements allowing their nationals to fish in the U.S. Fishery Conservation Zone. In 1984, NMFS issued 21 general permits to foreign and domestic fishing associations. While tuna/porpoise interaction has been one of the most complex problems in administering the Act, significant progress had been made in reducing porpoise mortality in commercial tuna fishing operations. NMFS operates an observer program on tuna vessels to monitor compliance with rules prescribed in concert with the general permit issued in 1980. Observers obtain biological data on porpoises captured during seining and provide estimates of mortality which NMFS uses to monitor the quotas. Since the current permit authorizing the take of porpoise incidental to the U.S. tuna fishery expires in 1985, NMFS has initiated the process for shaping the management regime that we will be implemented in 1986 and thereafter.

Four of the NMFS regions have developed Marine Mammal Stranding Networks that include individuals and organizations that volunteer to cooperate with NMFS and that are authorized to collect specimens for scientific research and record the event with the regional coordinator. Sick and injured animals are rehabilitated in voluntary centers. After rehabilitation, healthy animals are returned to the wild. Animals that cannot be returned to the wild are used for scientific research or public display.

The Endangered Species Act

The Endangered Species Act (ESA) authorized activities to conserve species that are either endangered now or are threatened with extinction in

the forseeable future. Under the Act, NMFS determines whether a marine species should be classified as endangered or threatened, develops and implements conservation programs, and consults with other Federal agencies on their actions that affect listed species.

NMFS recently completed its first 5-year review of most species listed under its jurisdiction to determine whether changes in the list are warranted. NMFS concluded the following proposed changes in the list are warranted: remove the Caribbean monk seal from the list, since the best available information suggests that it is extinct; list the eastern North Pacific or California stock of the gray whale as threatened, rather than endangered, since it has recovered to near its original population size; and reclassify the nesting populations of olive ridley sea turtles as endangered rather than threatened in the western north Atlantic (Surinam and adjacent areas).

The ESA allows interested persons to petition the Secretary of Commerce to add or remove species from the List of Endangered and Threatened Species that is maintained and published by the Fish and Wildlife Service. If the petition presents substantial information that supports the proposed action, NMFS must review the status of the species using the best scientific and commercial data available. NMFS has completed a status review of the California harbor porpoise and has proposed to list it as endangered. A status review of the Guadalupe fur seal and the North Pacific fur seal are now in process. A petition to list the Atlantic striped bass has been rejected; however, NMFS is concerned about this declining migratory species and will continue to monitor its stocks, especially in the Chesapeake Bay.

The ESA requires all Federal agencies to determine whether certain of their actions may affect a listed species. If the agency determines that the

action may do so, that agency must formally consult with NMFS on the action. NMFS then issues a biological opinion on whether the action is likely to jeopardize a listed species and offers reasonable and prudent alternatives to the action. For example, Federal permits or leases that allow oil and gas exploration or drilling in the outer continental shelf area usually require the Minerals Management Service to consult with NMFS. In FY 85, their activities in the Beaufort Sea, the Bering Sea, the south and north Atlantic Ocean, the Gulf of Mexico, and offshore California, required consultations and scientific opinions.

In the Gulf region, the NMFS conservation program for Kemp's ridley sea turtles continued with 191 of the 1983 year-class released off Texas during June and 1,441 hatchlings of 1984 year-class received for rearing. For stock assessment, a comprehensive Kemp's ridley survey and reporting network was established in the northern Gulf of Mexico.

The turtle excluder device (TED) design was signficantly improved. The new design is collapsible, made of steel or fiberglass, and has better handling characteristics and durability. The new model should encourage voluntary use by shrimp fishermen because the TED performs well with no shrimp loss, and with consistent finfish incidental catch reduction rates of 50 percent or better during day and night.

Aerial surveys and data acquisition off the Atlantic coast from Cape Hatteras to Key Biscayne provided necessary information for population assessments of loggerhead and leatherback sea trutles. Also, population estimates of bottlenose dolphin populations from the Florida east coast to Texas were produced.

The Marine Mammal and Sea Turtle Stranding and Salvage Networks were maintained, and reports were issued to constituents.

The University of Maine is investigating interactions between harbor seals and commercial gill net fisheries in the Gulf of Maine. Animals taken and killed incidentally are examined to calculate fishing mortality rates. These data allow NMFS investigators to evaluate the effects of these fisheries on the harbor seal population.

The National Marine Mammal Laboratory of NMFS conducts research on whales and other marine mammals to assess their abundance and ensure their survival. Much of this work is carried out in the Alaska Region, but a good part is also done along the west coast as well as in other parts of the world. This work carries over into the NMFS Southwest Region and into areas outside the boundaries of the United States.

Information

A NOAA Estuarine Programs Office was established in NMFS in 1984 to coordinate estuarine research within NOAA and to disseminate estuarine information within NOAA and throughout the estuarine research community.

Major efforts to improve the dissemination of fisheries-related information to the user community were made, such as establishing a protocol for use by the Army Corps of Engineers for information on commercial fisheries to assess port development projects.

NMFS has responded to requests from the Department of Agriculture for information on effects of agriculture on fisheries, and has worked to improve information provided to the Minerals Management Service for their decisions about offshore lease sales.

Fishery Statistics

The NMFS Fishery Statistics Program collects data on the volume and value

of U.S. commercial fishery landings, employment of craft and people in the commercial fisheries, foreign trade in fishery products, ex-vessel and wholesale fish and shellfish prices and other economic data, and cold storage holdings of fishery products. The program also collects data on marine recreational fishery catches, participation in marine recreational fisheries, and economic data on the industry. These statistics are collected in cooperation with the various states. The program conducts other special surveys, such as seafood consumption, and collects biological samples and measurements (e.g., fish size, sex, and otoliths for fish aging) for analysis by NMFS scientists.

With the signing of a cooperative state/Federal statistics agreement with Texas, NMFS now has agreements with all southeastern coastal states, Puerto Rico, and the Virgin Islands. These agreements assign responsibility for the collection of fishery statistics and provide arrangements for the storage and exchange of statistics on a NMFS-operated computer system.

Data Management

The National Data Management Program has developed several automated information systems to assist in the administration and internal control of key NMFS programs. All of these systems are nation-wide in scope and feature on-line data entry and information retrieval.

The National Ocean Service (NOS) carries out a diverse program of marine reasearch in support of its responsibilities as the nation's nautical chart maker and tide predictor, and to provide information needed for effective management of the nation's coastal zone.

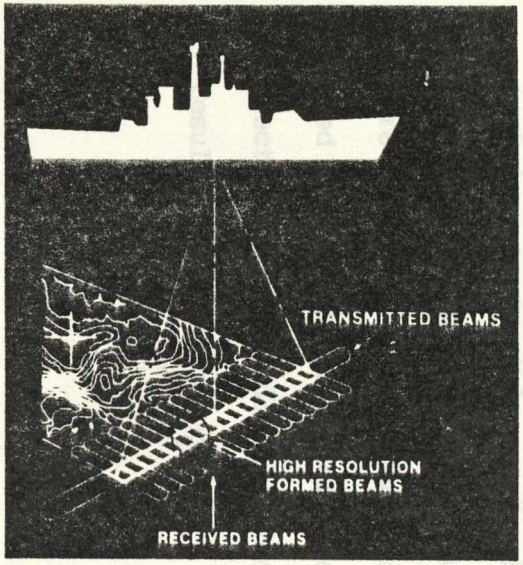
Charting and Geodetic Services

Recent accomplishments in charting and geodetic services (C&GS) are as follows: 1) new mapping programs and charting products; 2) improved marine surveying systems; and 3) application of space-age geodetic techniques to marine research problems.

New Mapping and Charting Products

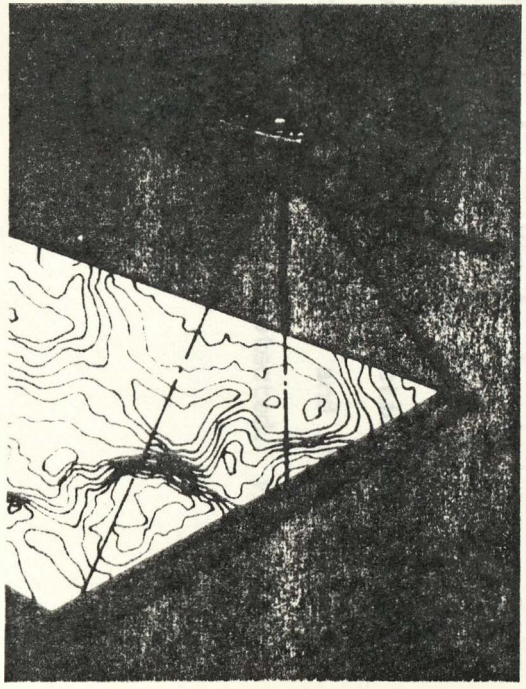
On March 10, 1983, the President proclaimed that the United States has sovereign rights in the Exclusive Economic Zone (EEZ), an area extending 200 nautical miles seaward of the coast, for the purpose of exploring, conserving, and managing the living and nonliving resources. Because bathymetric maps are needed by government and the private sector to carry out these activities, NOS has embarked on a program to provide high resolution bathymetric surveys for the highest priority areas of the EEZ. NOAA Ships SURVEYOR and DAVIDSON using multi-beam swath systems have begun surveying the California EEZ.

Traditional C&GS marine navigational products have been displayed on paper chart and book formats. Recent C&GS efforts have been directed toward making marine mapping and charting data available to users in a digital format as well. These digital data could be used to produce "electronic charts" that can be displayed on video monitors on the bridge of a ship. The increased use of digital data can increase the speed of dissemination of the latest navigational information to the user.

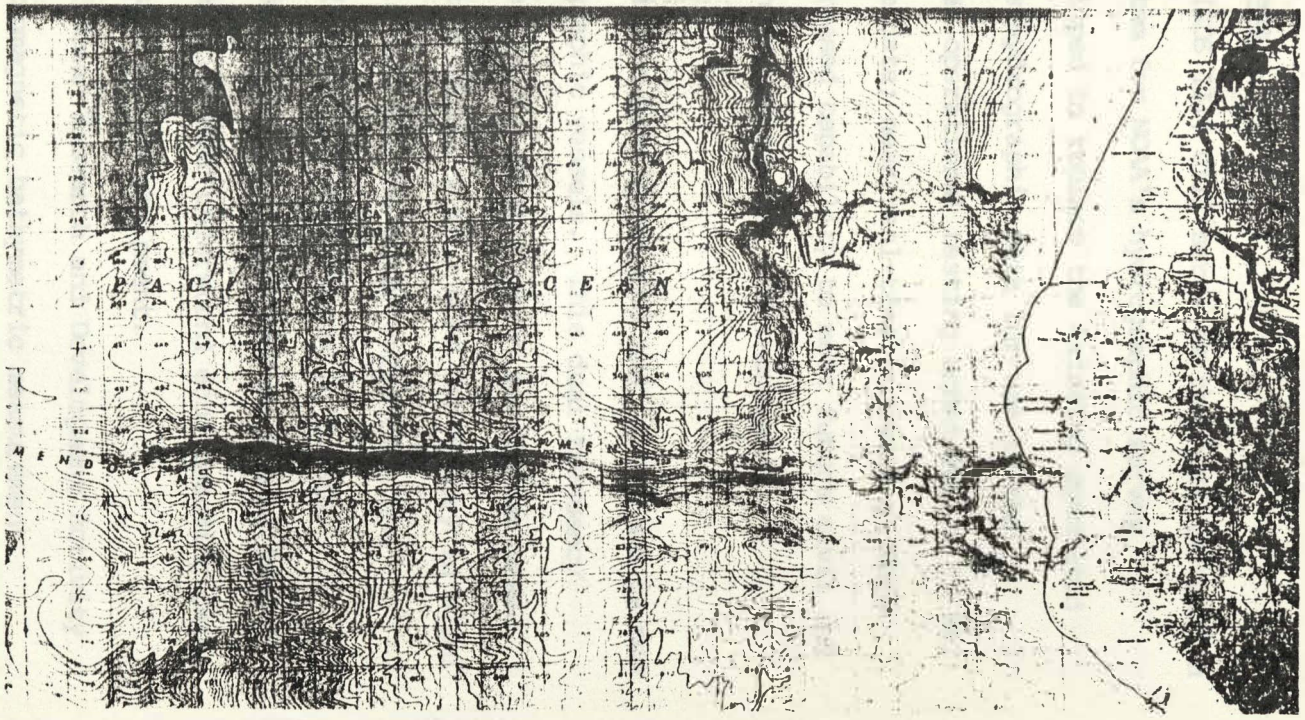


Swath technology uses multiple sonar beams to map a swath of the sea floor.

High-resolution swath bathymetry, produced from the Sea Beam System, of an area off California.



Contours of sea-floor relief are produced aboard the ships.



Bathymetric map of an area off northern California from conventional survey methods.

Improved Marine Surveying Systems

The Shipboard Data System III (SDS III) will serve as the next generation data acquisition and processing system for NOAA's hydrographic survey vessels. This system is being developed to replace the existing automated data systems that gather and process hydrographic data for use in the production of nautical charts. After operational testing scheduled in FY 86, SDS III will provide: more accurate data; near real-time processing; more effective use of NOAA shiptime; increased capability to meet future civil and military defense mapping and charting requirements; and increased productivity.

A new shallow-water echo sounder has been developed and tested and is now standard equipment for NOAA's hydrographic vessels. This dual frequency system significantly improves our ability to cover a given sea bottom area.

Last year, NOS began a cooperative effort with a NOAA laboratory in Miami to study the transmission of acoustic signals and their reflection and scattering from the diverse types of sediments encountered in coastal waters. The goal is to develop a good model of how echoes are formed from bottom acoustic interactions in order to better understand echo sounding data, improve accuracy, and aid in the design of new equipment.

The NOS participated with Naval Ocean Research and Development Activity (NORDA) in testing an airborne electromagnetic bathymetric measurement technique to remotely acquire hydrographic data. NOS developed the ground truth for the tests off Cape Cod in waters up to 60 meters depth. The sensors were towed above the water by a helicopter. An electromagnetic source was used to generate electrical eddy currents in the seawater, and the secondary electromagnetic fields produced by these currents were detected. Preliminary results are encouraging.

The NOS is supporting the High Energy Benthic Boundary Layer Experiment (HEBBLE) using the analytical stereoplotter for deep sea microphotogrammetry in response to requests from Woods Hole Oceanographic Institute and the Office of Naval Research. The objective of HEBBLE is to predict the response of deep sea sediments to deep ocean currents and other forces. This modern system has generated 1:1 plots of small portions of the ocean floor, thousands of meters below the surface.

Application of Space-Age Geodetic Techniques to Marine Research

In January 1984, the Richmond Observatory (near Miami, Florida) became operational, thus completing the three-station Very Long Baseline Interferometry (VLBI) network in the United States. Radio telescopes at these stations observe signals emitted by faint, distant, radio sources (typically quasars) that are located billions of light-years from the Earth. This allows monitoring of polar motion and variations in the rate of rotation with the highest accuracy yet attained. A correlation has been found between values of atmospheric angular momentum, indicating a mechanistic link between Earth rotation and weather. A strong peak in the value of length-of-day coincided with the strongest episode of the El Nino phenomenon to have occurred in this century.

Advances in space technology have made possible the determination of geodetic parameters that heretofore were thought to be unattainable. An important example is the measurement of sea-surface topography by satellite altimetry. In applying satellite altimetry data to the study of the undulations of the geoid, a correlation was found with seafloor topography. The gravitational attraction of massive seafloor features such as seamounts, trenches, ridges, oceanic rises, and fracture zones produce bumps on the sea surface that can be mapped by satellite altimetry. Last year, NOS produced 32

overlays of sea-surface topography profiles for 16 maps of the General Bathymetric Chart of the Oceans Series. In poorly charted areas, the satellite altimeter has revealed many previously undetected features of the seafloor; nearly 100 previously undiscovered seamounts were found in the South Pacific, clearly demonstrating the potential of this method as a powerful reconnaissance tool.

In FY 84, progress was made toward the ultimate goal of determining long-term general circulation of the oceans from satellite altimetry data with the preparation of a global map of ocean circulation. C&GS also developed satellite altimetry techniques to monitor the short-term sea-level changes caused by El Nino with an accuracy of a few centimeters.

Analyses of tide gauge time series data have suggested that global sea level may be rising at an increasing rate, possible due to the melting of the polar ice caps as a result of the "greenhouse effect." Traditional measurements using tide gauges are difficult to interpret because of crustal movements. When the gauges are referenced to the absolute global reference frame provided by the VLBI/Global Positioning System network, it should be possible to monitor long-term and large-scale sea level variablity. C&GS is commencing in 1985 a program to tie selected U.S. tide gauges to the global network.

Tides, Water Levels, And Circulation

A total circulation numerical model for the Delaware River and Bay was demonstrated during September 1984. Using tidal current information and real-time water level and meteorological information from key locations in the estuary, the model permits predictions of water levels and currents for up to 36 hours in the future. In addition, the model permits assessments of the effects of extreme events, such as severe storms, on water levels and

currents. In a number of areas, the utility of traditional tidal current predictions is limited because river runoff and meteorological conditions are also major forces affecting circulation. As part of the operations in the Delaware River and Bay, two new technologies were also tested. A remote acoustic doppler system mounted in the bottom of a vessel allows observations on currents in major ship channels and other areas which are not accessible with existing instrumentation. The other radar-based technique measures waves and surface water movements from shore-mounted units.

In cooperation with the Department of the Interior and the State of Alaska, water level instrumentation was installed to permit marine boundary determinations on the Western Slope, an area of offshore oil and gas development. The extreme operating environment, difficulty in accessing stations, and permafrost create a significant technical challenge. When completed, the system will transmit data to NOS in Rockville, Maryland, by satellite for processing and analysis, and the results will be returned to Alaska by satellite.

Technical assistance was provided to the State of New York for the establishment and operation of a real-time water level and meteorological observation and reporting system to serve navigation interests in New York Harbor. Four stations provide information to the Maritime Association of the Port of New York, which in turn provides the information to subcribers. Regional workshops were held to determine requirements for such systems in other coastal areas and the Great Lakes. In general, local interests are expected to provide the specialized products and services required by non-federal navigation interests. However, NOS provides technical advice and access to information from those of its 225 permanent water level observation stations which have telemetry capabilities. As with currents, tide

predictions based on the relative movements of the sun, earth, and moon are not adequate, particularly for deep-draft vessels using shipping channels.

Development and implementation have begun on a Next Generation Water Level Measurement System (NGWLMS), designed to facilitate rapid access to information from stations, improve tide and water level products and services, and reduce operating costs. When the NGWLMS is fully implemented around the end of the decade, all permanent and temporary stations will transmit data by satellite several times a day. This system will detect station malfunctions more rapidly, thereby improving data quality, and greatly reducing the time period (now 45-60 days) between the collection of data and its availability to users. Particularly for the datums used for marine boundaries and nautical charting and for tide predictions, it is important to have complete, long-term records. With the NGWLMS, all stations will also have the capability to add sensors, e.g., for meteorological parameters, and to be interrogated by telephone or short-range radio. This will enhance multi-purpose use of stations for Federal, state, and local purposes.

Ocean Assessments

Assessment activities carried out by the NOS range from comprehensive long-term assessments of national marine environmental quality issues to on-scene, real-time assessments leading to advice about corrective actions to be taken during emergency responses to spills of hazardous materials. Related research activities range from laboratory research focused on the fundamental processes that determine the distribution, movements, and effects of pollutants in the marine environment to characterization of the current status and long-term trends in marine environmental quality throughout the nation's coastal waters.

Ocean Dumping Rearch

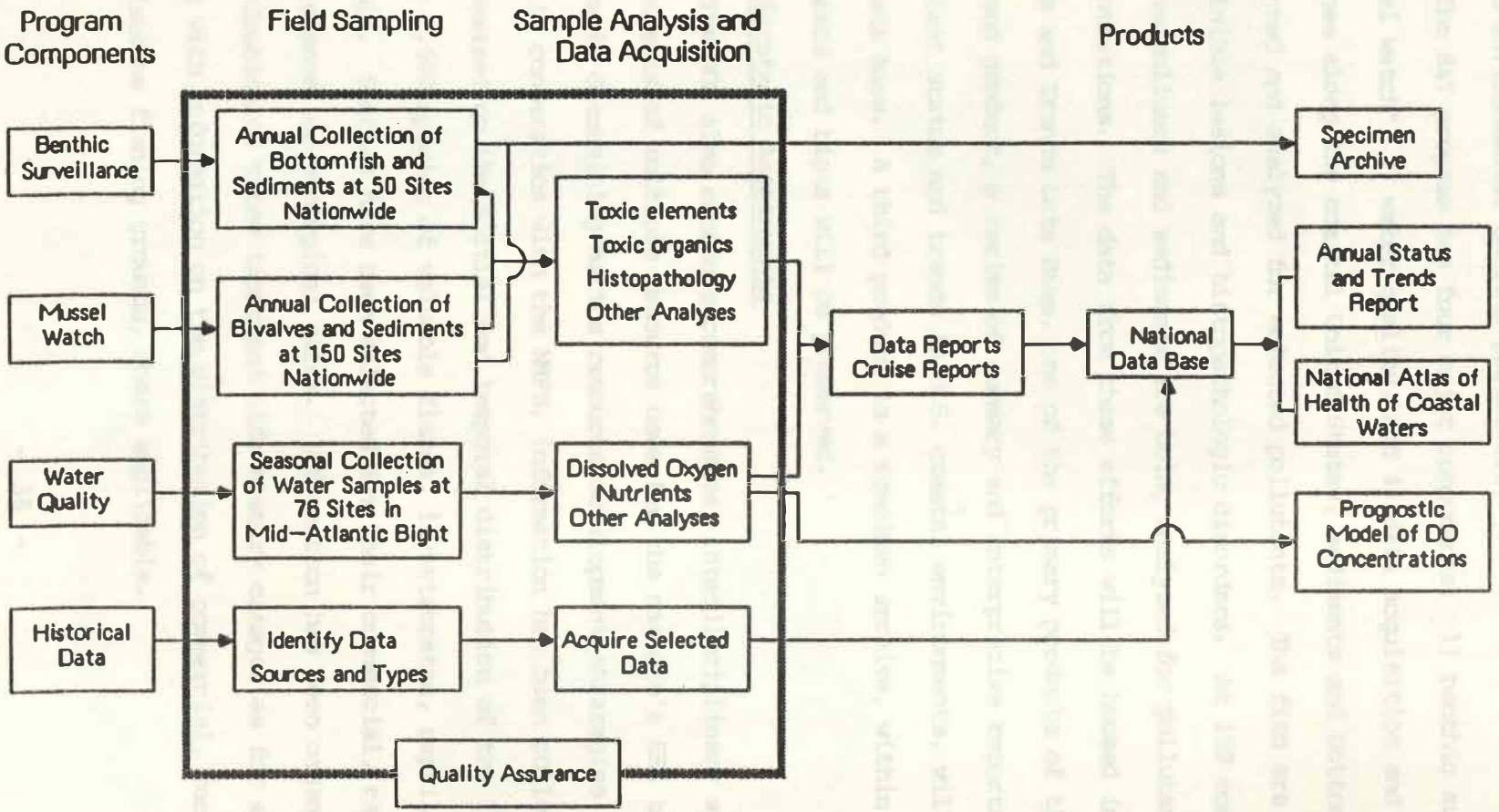
Extensive research and assessment effort has been directed at the effects of ocean dumping, focused especially on present and proposed sewage sludge dumpsites off the coasts of New York and New Jersey. Studies of the Gulf Stream eddies that traverse the continental slope in this region showed that the eddies would be more effective at enhancing dispersion within the slope regime than in moving wastes westward across the shelf. Studies on sludge-settling behavior have shown that the rate of coagulation, and therefore the number of faster settling particles, depends critically on the initial concentration of sludge. To minimize the settling of particles at a dumpsite, therefore, the sludge should be diluted as much as possible upon dumping.

Except for contamination associated with sinking particles, the result of ocean dumping is contamination of the ocean's upper mixed layer, where biological response to that contamination might be evident among planktonic organisms. Laboratory experiments have demonstrated changes in zooplankton reproduction and growth which, if they were to occur over a large enough area, could yield population changes. Population and community changes related to waste disposal have not been detected in field measurements however, probably because of the high variability of natural populations and hydrographic conditions governing plankton dispersal.

Status and Trends of Marine Environmental Quality

In FY 84, NOS initiated a program called the National Status and Trends (S&T) Program, to establish and maintain the information base required to quantify the current status and long-term trends of key contaminant concentrations, water quality parameters, and biological indicators of effects in the nations's coastal and estuarine environments. Key questions the program intends to answer are: 1) what are the current conditions of the

NATIONAL STATUS AND TRENDS PROGRAM



Schematic showing the four components of the program, how the data acquired will be integrated into a national data base, and the anticipated final products.

nation's coastal zone; and 2) are these conditions getting better or worse? A nationally uniform set of measurement techniques will be employed to determine marine environmental quality parameters.

The S&T program has four major components: 1) benthic surveillance, 2) "mussel watch", 3) water quality, and 4) data acquisition and compilation. At 50 sites along the coastal United States, sediments and bottomfish are being collected and analyzed for selected pollutants. The fish are also examined for visible lesions and histopathologic disorders. At 150 coastal sites, bivalve molluscs and sediments are being analyzed for pollutant concentrations. The data from these efforts will be housed in a National Status and Trends Data Base, one of the primary products of the S&T program. A second product, a series of summary and interpretive reports on the pollutant status and trends in U.S. coastal environments, will be derived from the data base. A third product is a specimen archive, within which samples of sediments and biota will be preserved.

Strategic Assessments

The NOS also conducts comprehensive, interdisciplinary strategic assessments of multiple resource uses for the nations's EEZ to aid decision - makers in determining marine resource development strategies.

In cooperation with the NMFS, information has been collected and synthesized on the spatial and temporal distribution of the life histories of about 3,000 species of valuable fishes, invertebrates, reptiles, and mammals. Species have been selected for their commercial, recreational, subsistence, or ecological value. Information has been organized on the distribution of three important life history categories for each species, along with information on the distribution of commercial, recreational, and subsistence fishing grounds, where applicable.

Red snapper

Lutjanus campechanus

Guachinango

Description

Range: The red snapper, a bony fish of the family Lutjanidae, is found along the western Atlantic from New England to the Yucatan Peninsula and throughout the Gulf of Mexico. It is particularly abundant on the Campeche Banks, the shelf areas of west Florida, and the northern Gulf.

Habitat: These demersal fish are found over sandy and rocky bottoms, around reefs and underwater objects at depths between 0 to 200 meters and possibly beyond 1,200 meters in the northern part of its distribution area. Adult red snapper favor deeper waters. Juveniles inhabit shallow nearshore and estuarine waters and are most abundant over sand or mud bottoms.

Feeding and Behavior: A common inhabitant of reefs, the red snapper feeds along the bottom on fishes and benthic organisms such as tunicates, crustaceans, and molluscs. Juveniles feed on zooplankton, small fish, crustaceans, and molluscs. The red snapper is a schooling species.

Reproduction: Spawning grounds are located in offshore waters and are active from June to October. Juveniles are found in estuaries and inshore coastal areas.

Movement: Little movement is shown by tagging studies, except possibly a general offshore movement in cold weather. As juveniles mature, they move into deeper waters.

Fisheries: Commercial fishing for the species in the Gulf is more extensive than for any other snapper, with year-round fishery reported off the coasts of western Florida to Texas and off the Yucatan. In terms of landed pounds, the red snapper is the largest component of the snapper fishery. The red snapper is highly esteemed as a recreational sport fish. Recreational fishing grounds are located offshore in the northern Gulf and both coasts of Florida.

References: Benson, N G., ed., 1982; Bradley, E., and C E. Bryan, 1974; Camber, C.I., 1955; Collins, L A., J H. Finucane, and L E. Barger, 1980; Fischer, W., ed., 1978; Gulf of Mexico Fishery Management Council, 1980b; US DOI, FWS Office of Biological

- Adult Area (Year-round)
- Major Adult Area (Year-round)
- Nursery Area (Year-round)
- Commercial Fishing Ground (Year-round)
- Recreational Fishing Ground (Year-round)

Spawning, from June to October, occurs throughout adult areas.

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Rivas, L R., pers. comm.

Strategic Assessment Branch
Ocean Assessments Division
Office of Oceanography and Marine Assessment
National Ocean Service/NOAA
and the
Southeast Fisheries Center
National Marine Fisheries Service/NOAA

Sample Map from the Gulf of Mexico Data Atlas, derived from the Living Marine Resource Life History Data Base.

This information is organized by 10-minute x 10 minute offshore "grid cells" and by the four seasons of the year. An automated data system has been developed that can produce computer-generated maps and statistical summaries of data on different combinations of species, life history stages, seasons of the year, and grid cells. The system is currently operational for the East Coast and Gulf of Mexico regions of the EEZ and will be finished for the Arctic coast by the end of 1985. The combined information on species life history and abundance helps to identify those areas of the EEZ that are relatively important biologically.

Marine environmental quality in the EEZ is affected by pollutant discharges from land-based sources, and from ships and other offshore structures. Existing information on each coastal and offshore source of water pollutant discharge is being compiled in a National Coastal Pollutant Discharge Inventory (NCPDI). The types of water pollutants being considered include: 1) oxygen-demanding materials, 2) nutrients, 3) heavy metals, 4) petroleum hydrocarbons, 5) synthetic organics, 6) sludges, and 7) pathogens. Source categories include all point, nonpoint, and upstream (riverine) sources in the coastal zone and EEZ.

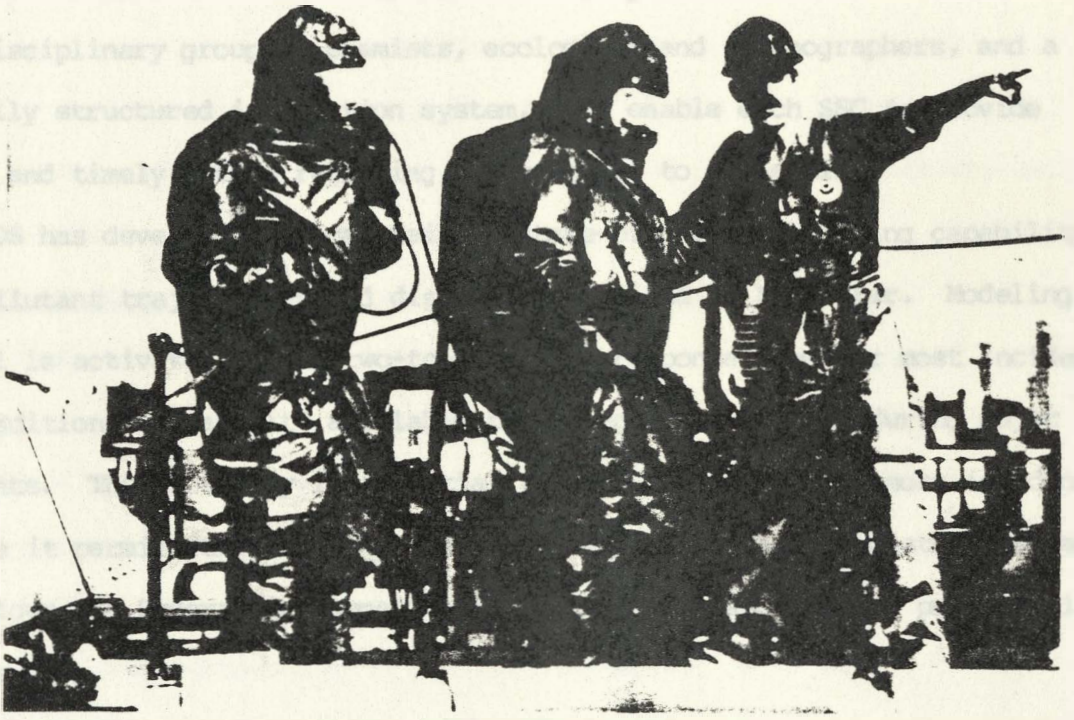
The Gulf of Mexico and East Coast components of the NCPDI have been completed. For the Gulf of Mexico, the inventory contains estimates for 17 water pollutant discharges for over 2,500 individual point sources, 260 urban areas, 450 offshore oil fields, all agricultural acreage in the coastal zone, and 90 rivers draining into the Gulf. Analogous estimates for the West Coast will be completed by the end of 1985. Production of sewage sludge has also been estimated for each of the more than 2,000 publicly-owned treatment plants throughout the U.S. coastal zone. The computational framework developed for the NCPDI permits various aggregations by water pollutant, source category,

individual source, and various spatial units, depending on the issue or problem of concern.

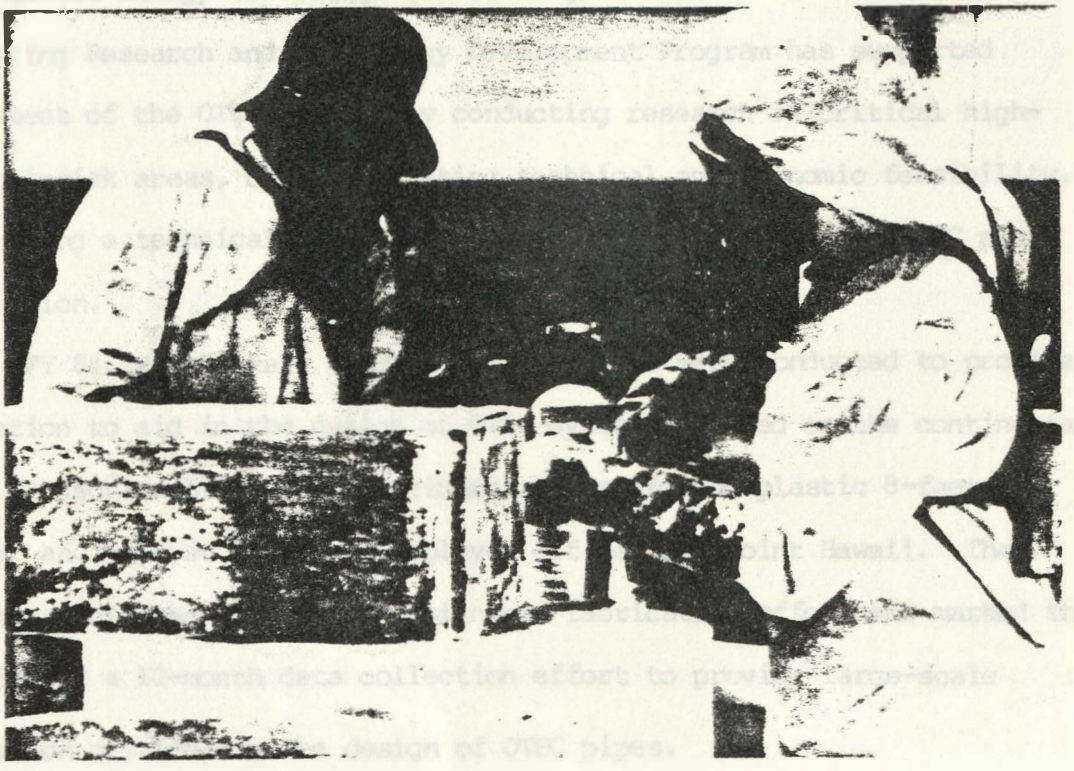
As a first step toward the systematic analysis of resource-use conflicts in estuaries, the NOS initiated a major project in FY 84 to: 1) delineate the physical and hydrologic boundaries of all large and medium-size estuaries in the nation; and 2) develop a data base on their important physical and hydrologic characteristics. This project will generate an atlas of maps containing all significant estuaries in the continental United States depicting the boundaries of the estuarine portions of drainage basins, the approximate boundaries of the tidal fresh, mixing zone, and sea water portions of each, and important physical and hydrologic data for each estuary. Future efforts will focus on the nature and extent of human activities, distributions and abundance of living marine resources, and trends in environmental quality. When completed, the National Estuarine Inventory will allow comparisons, rankings, statistical correlations and analyses related to resource use, environmental quality, and economic values among esturaries.

Hazardous Materials Response

The transportation of oil and hazardous materials through coastal and estuarine waters poses potential threats to marine systems. When a major accidental spill of a hazardous material occurs, an immediate decision is necessary as to which course of action should be taken in order to minimize damage to the marine environment. The NOS maintains a highly-trained team of regional Scientific Support Coordinators (SSCs) who can be mobilized quickly to the scene of an accidental spill to assess: 1) the type, quantity, location, and movement of the material; 2) the immediate and long-term availability of the contaminant (or its degradation products) to the biota, 3) the sensitivity of the habitats that could be affected, and 4) the feasibility



HAZMAT spill drill in the Port of Philadelphia



Emergency disposal of GASTOXIN containers from the vessel RIO NEUQUEN August, 1984.

and costs of containment and cleanup of the material. The SSCs are supported, through a nationwide communications network, by a close-knit, interdisciplinary group of chemists, ecologists and oceanographers, and a carefully structured information system, that enable each SSC to provide expert and timely advice regarding the response to the spill.

NOS has developed and maintains a state-of-the art modeling capability for pollutant trajectories and distribution on and in the water. Modeling of a spill is activated with a two-to-four-hour response time for most incidents, with additional capability available to be deployed on-scene during major incidents. This activity is essential to the SSC function in most incidents, because it permits the SSC to provide forecasts of pollutant distributions, and allows the Federal On-Scene Coordinator to take appropriate preventative actions.

Ocean Thermal Energy Conversion: Ocean Engineering

NOAA has provided ocean engineering support to the Department of Energy's Ocean Thermal Energy Conversion (OTEC) Program since 1976. The NOAA Ocean Engineering Research and Technology Development Program has supported development of the OTEC concept by conducting research in critical high-technical-risk areas, by demonstrating technical and economic feasibility, and by providing a technical information base for use in design of OTEC plant construction.

In FY 84, small-scale cold water pipe tests were conducted to provide information to aid in the design of OTEC systems mounted on the continental slope. A section of test pipe, fiberglass-reinforced plastic 8-feet in diameter and 80-feet long, was deployed off Keahole Point Hawaii. The deployment followed an 8-month design and fabrication effort and marked the beginning of a 12-month data collection effort to provide large-scale information critical to the design of OTEC pipes.

Marine and Estuarine Sanctuary Programs

Research carried out by the Marine and Estuarine Sanctuary Programs of NOS is designed to enhance scientific understanding of national marine sanctuary environments, improve public awareness and wise use of marine resources and ecosystems, and provide information needed by sanctuary managers and decisionmakers to resolve management issues.

The Capacity for Sanctuary Resources to Sustain Use

Marine sanctuaries are visited by many people for a variety of reasons. In many cases, the ecological status of the sanctuary is poorly known and patterns of human visitation and resulting impacts on sanctuary resources have not been adequately documented or assessed. A major management issue is that, in the face of ever-increasing demands on sanctuary resources, the capacity of the resources to sustain use is not fully known.

The Key Largo National Marine Sanctuary and the Looe Key National Marine Sanctuary in the Florida Keys, for example, are visited each year by increasing numbers (hundreds of thousands) of persons who are drawn to the sites because of outstanding coral reef features, accessibility to major population and vacation centers, and national exposure through press and media. The resources at these sites are subject to physical damage, such as damage to coral from specimen collecting, anchoring, boat groundings and careless diving practices, and it is currently unknown what impact these chronic disturbances might have on the long-term health of the system. All the other designated sanctuaries (i.e., the Gray's Reef National Marine Sanctuary off Georgia, the U.S. MONITOR National Marine Sanctuary off North Carolina, and the Channel Islands National Marine Sanctuary and the Point Reyes National Marine Sanctuary off California are also vulnerable to human activity. Another concern is activity originating outside the sanctuary

boundaries, such as coastal development, dredging, pollution, and oil spills, which pose a threat to sanctuary resources.

Programs initiated to address these issues include: 1) research to improve our understanding of the systems' biological structure; 2) on-site visitor surveys to establish visitor-use patterns and developing management strategies to alleviate visitation pressures and 3) research and monitoring programs to study the ecological effects of natural and man-caused disturbances on the sanctuary environment.

The Significance of the Sanctuary Environment to Rare, Endangered, or Otherwise Important Marine Species

In many cases, Marine sanctuaries are refuges for the last breeding population of a species, for populations that are experiencing dramatic changes in population dynamics, for populations that are in direct competition with humans for limited resources, or for populations that are unduly stressed by human interference. In California's Channel Islands National Marine Sanctuary and Point Reyes/Farallon Islands National Marine Sanctuary, for example, populations of pinnipeds, cetaceans, and seabirds are of management concern for many of these reasons. In these and other sanctuaries, where certain resident and migratory populations are of special interest, research and monitoring programs are providing sanctuary managers with information on population dynamics, food resource utilization, and habitat requirements. Projects are also underway to inform visitors that sanctuary resources are sensitive to human disturbances.

Vulnerability of Submerged Artifacts

Submerged beneath the coastal waters of the United States is a wealth of information regarding the history of maritime exploration, commerce and warfare, the evolution of ship design, and the cultures of prehistoric and historic human occupation of the coast. Few U.S. coastal areas have been adequately surveyed to discover what submerged treasures actually exist. In an effort to preserve historic and cultural resources in national marine sanctuaries and to ensure their systematic recovery, research is underway to produce the data required for responsible management decisions relative to the fate of the resources. In the U.S. MONITOR National Marine Sanctuary, research in the ten years since that vessel was discovered has provided valuable data including video tape records of the wreck site, an assessment of the MONITOR's rate of deterioration, and actual recovery of parts of the vessel.

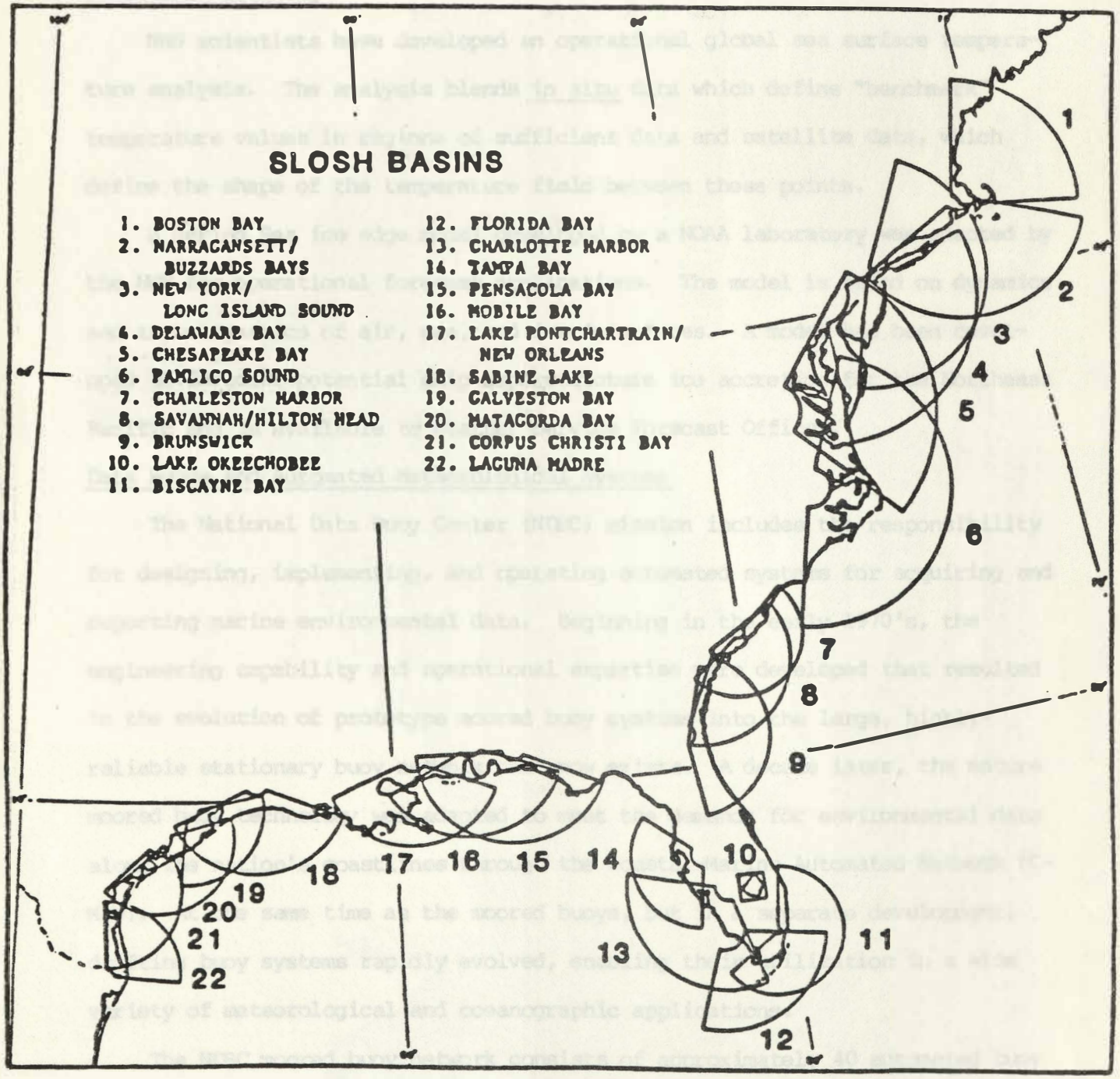
The mission of the National Weather Service (NWS) is to provide accurate and timely warnings and forecasts of weather conditions to ensure the safety of the population, mitigate property losses, and improve the economic efficiency of the nation. In support of that mission, the NWS carries out programs of research which involves development of new or improved observation and forecast techniques. The marine-related research of NWS during the period FYs 82-85 is described in the following material.

Marine Forecast Technique Development

Hurricane Storm Surge Forecasting. The dynamic hurricane storm surge model, SLOSH (Sea, Lake, and Overland Surges from Hurricanes), was adapted to five additional coastal areas in FY 82. Two areas were adapted in early FY 85.a SLOSH is now available for 22 areas along the Gulf of Mexico and Atlantica coasts for real-time hurricane storm surge forecasting. The SLOSH model considers the inland routing of sea water, overtopping of barriers, flow of water through gaps in barriers, and flow through channels. In areas where SLOSH is not yet available, the SPLASH model, a less sophisticated model which treats the surge only up to the open coast, continues to be used operationally. SLOSH is also being used extensively as a tool for hurricane evacuation planning. Through a series of SLOSH computer simulations of hypothetical hurricanes, areas of potentialaflooding are delineated. SLOSHa also aids in predicting the timing of surge and winds associated with hurricanes. Model improvements to SLOSH continue to be made. A treatment of river banks with their associated changes to the surge flow has been added.

Coastal and Oceanic Forecasting. Experimental tests continue on a computer-generated program that provides worded forecasts for the Atlantic and Pacific Ocean high seas areas. Experimental computer-generated weather

NOAA's Hurricane Storm Surge Forecasting Model



The hurricane storm surge model, SLOSH (Sea, Lake, and Overland Surges from Hurricanes) was developed by the National Weather Service as an aid in predicting the timing of storm surges and winds associated with hurricanes. The map shows the 22 coastal areas now covered by SLOSH.

forecasts are provided to the forecast offices in Washington and San Francisco, where they are under evaluation.

Numerical Modelling

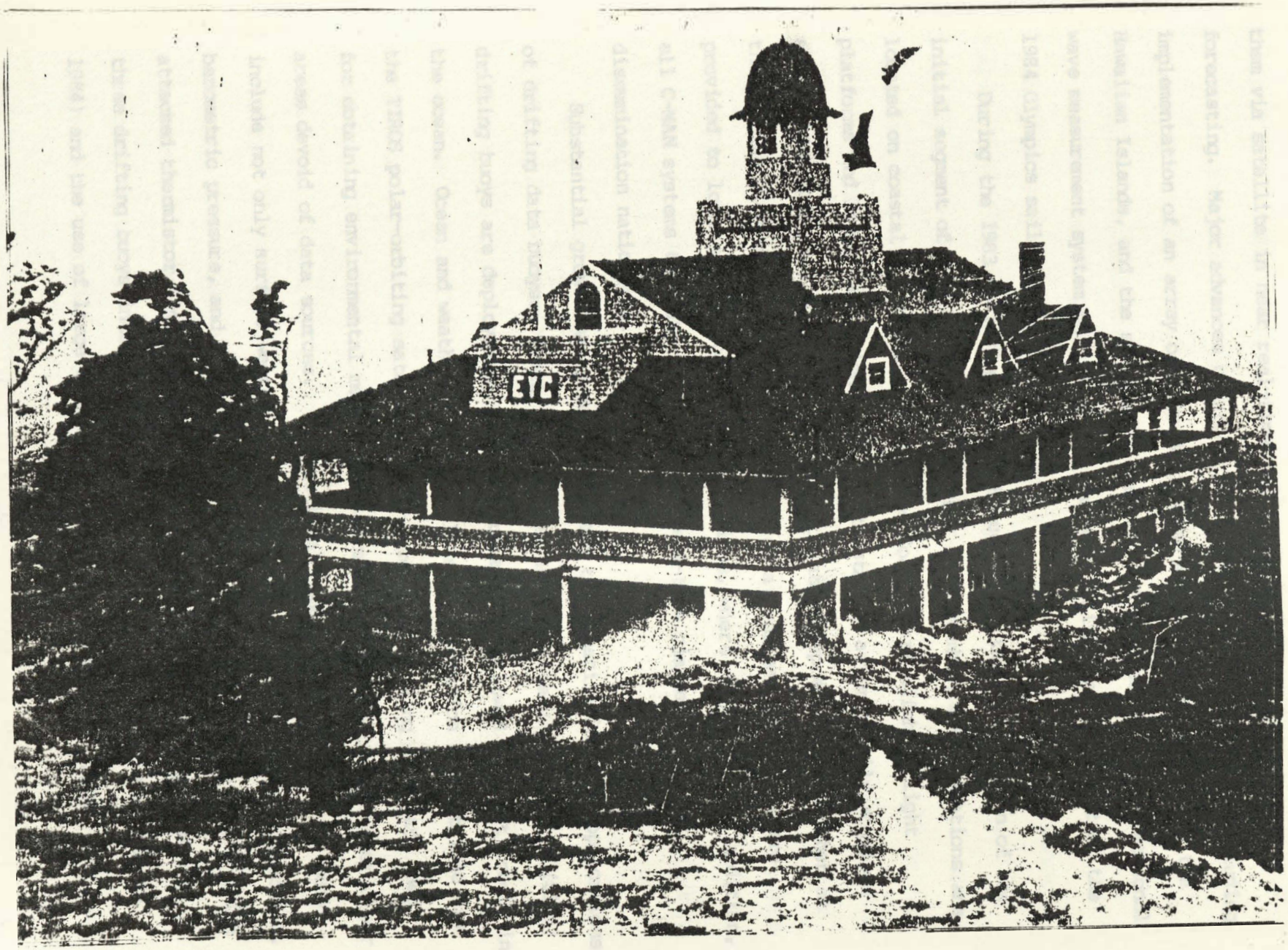
NWS scientists have developed an operational global sea surface temperature analysis. The analysis blends in situ data which define "benchmark" temperature values in regions of sufficient data and satellite data, which define the shape of the temperature field between these points.

A Bering Sea ice edge model developed by a NOAA laboratory was adapted by the NWS for operational forecast applications. The model is based on dynamics and thermodynamics of air, sea, and ice interfaces. A model has been developed to forecast potential ship superstructure ice accretion for the Northeast Pacific and is available to Weather Service Forecast Offices.

Data Buoys and Automated Meteorological Systems

The National Data Buoy Center (NDBC) mission includes the responsibility for designing, implementing, and operating automated systems for acquiring and reporting marine environmental data. Beginning in the early 1970's, the engineering capability and operational expertise were developed that resulted in the evolution of prototype moored buoy systems into the large, highly reliable stationary buoy network that now exists. A decade later, the mature moored buoy technology was adapted to meet the demands for environmental data along the nation's coastlines through the Coastal-Marine Automated Network (C-MAN). At the same time as the moored buoys, but in a separate development, drifting buoy systems rapidly evolved, enabling their utilization in a wide variety of meteorological and oceanographic applications.

The NDBC moored buoy network consists of approximately 40 automated buoy stations off the coasts of the United States and in the Great Lakes. The buoys acquire marine surface meteorological and wave observations and relay



Hurricane Carol floods Edgewood Yacht Club in Providence, RI, September 30, 1954.

them via satellite in near real-time for use in weather analyses and forecasting. Major advances occurred in FY's 1983, 1984, and 1985, including implementation of an array of four deep-ocean moored buoys surrounding the Hawaiian Islands, and the successful operation of an experimental directional wave measurement system on a buoy off southern California in support of the 1984 Olympics sailing competition.

During the 1983 to 1985 period, NDBC completed the installation of the initial segment of C-MAN. Totalling nearly 50 in number, C-MAN stations are located on coastal headlands, islands, and Coast Guard offshore light platforms and large navigation buoys. Each station automatically acquires surface environmental observations that accurately represent the weather at the critical land-sea juncture. Formatted data from headland sites are provided to local weather offices by landlines, where available. In addition, all C-MAN systems telemeter data in near real-time via satellite for dissemination nationwide.

Substantial growth has occurred in both the capabilities and applications of drifting data buoys. Small, expendable, and relatively inexpensive ($10K) drifting buoys are deployed by ship or aircraft and allowed to drift freely in the ocean. Ocean and weather data as well as buoy position are obtained via the TIROS polar-orbiting satellites. As a result, drifting buoys are ideal for obtaining environmental measurements from remote oceanic regions or other areas devoid of data sources. Observational capabilities of drifting buoys include not only surface weather parameters such as wind speed and direction, barometric pressure, and temperature, but also subsurface temperatures using attached thermistor lines. Recent developments include the deployment of three drifting buoys into the path of a hurricane (Hurricane Josephine in 1984) and the use of large quantities of drifting buoys to support the

Tropical Ocean Global Atmosphere (TOGA) experiment. TOGA is concerned with quantifying the effects of ocean-atmosphere dynamics, such as the El Nino/ Southern Oscillation phenomenon, on global climate.

NOAA/NWS Tsunami Warning Service

The NWS maintains operational support for tsunami warning services through the operation of the Pacific Tsunami Warning Center and the Alaska Tsunami Warning Center. Administrative support and facilities are also provided to the International Tsunami Information Center in Honolulu. Efforts to improve the Tsunami Warning Service have proceeded in many areas. In 1983 real-time seismic data exchange was established with the U.S. Geological Survey so that both the Pacific and Alaska Tsunami Warning Centers now have sufficient seismic data available in real-time to rapidly locate and evaluate earthquakes throughout the Pacific. In 1984 seismic data was being computer-processed in real-time to provide faster earthquake location and magnitude information.

Applied research begun in 1984 is being continued for areas designated as seismic gaps to evaluate the potential tsunami threat throughout the Pacific and to improve operational procedures. Research is also continuing in the development of a predictive tsunami impact capability using an empirical analysis of historical data, combined with probability studies for tsunami generation. The initial predictive capability will be completed in 1985 for the Hawaiian Islands for application in real-time during a tsunami warning emergency. The concept will gradually be enlarged to apply to other coastal states and then throughout the Pacific.

In order to improve tsunami data acquisition, tide platforms are being installed at strategic locations in the Pacific to transmit required tidal data via the Geostationary Orbiting Environmental Satellite (GOES) in a near

real-time mode. The first units were operational in 1984-85 at Johnston Island; at Rarotonga, Cook Islands; at Nauru; and at Majuro, Marshall Islands. Other units will be installed at coastal and island locations in the Pacific during the remainder of the decade. These installations are being accomplished in coordination with research efforts at the University of Hawaii and Oregon State University in support of the Integrated Global Ocean Services System (IGOSS) and TOGA. It is through the continued application of satellite technology that required seismic and tidal data can be transmitted to the Warning Centers in near real-time to improve the response time for detection and evaluation of tsunamis, which pose a threat to the United States and other nations in the Pacific.

NATIONAL ENVIRONMENTAL SATELLITE, DATA, AND INFORMATION SERVICE

The National Environmental Satellite, Data, and Information Service (NESDIS) has responsibility for all of NOAA's satellite operations, as well as acquisition, storage, retrieval, and dissemination of scientific data and information derived from NOAA's research and monitoring activities. The NESDIS made significant contributions to various agency marine-related programs or activities during the FY 82-85 period. These are described in the following material.

Deep Seabed Mining - Sea Surface Monitoring

A study was initiated in 1982, and is continuing into 1985, to evaluate the potential of satellite remote sensing as an independent tool for observing potential surface and near-surface environmental effects of ocean mining. This research is carried out in support of NOAA's monitoring responsibilities under the Deep Seabed Hard Mineral Resources Act (P.L. 96-283).

The objectives are to establish high-resolution, satellite-derived baseline data of the tropical Pacific Ocean from which oceanic variations may be measured against long-term mean conditions. Research involves the acquisition and analyses of data sets from the NOAA polar orbiter's Advanced Very High Resolution Radiometer (AVHRR) and the NASA Nimbus-7 Coastal Zone Color Scanner (CZCS).

Preliminary analyses of both AVHRR and CZCS satellite images indicate that sea surface temperature (SST) and chlorophyll concentrations in the proposed mining sites are within the measurement capabilities of both instruments for cloud-free areas.

Ocean Thermal Energy Conversion (OTEC)

Research was undertaken in 1982-1984 to determine the potential utility of satellite-borne sensors for monitoring the environment in the vicinity of planned OTEC facilities. A case study was completed on a potential OTEC site near Punta Tuna, Puerto Rico, using data from the AVHRR flown on the NOAA-7 polar orbiting satellite. Selected AVHRR images were analyzed to determine seasonal differences in the SST field near Punta Tuna, and to estimate the magnitude of localized SST anomalies detectable in AVHRR data.

Time series measurements from the AVHRR were analyzed for the naturally occurring SST variations in 1982 for the ocean area near Punta Tuna to provide input to baseline data for establishing normal SST variability. Average ocean surface temperatures for the Punta Tuna site were comparable to historical *in situ* measurements, and the agreement between the AVHRR and *in situ* measurements was in line with that found by other investigators.

In addition, this research addressed the question of how large OTEC-related changes must be in order to be observable with AVHRR-type infrared sensors. Initial results show that OTEC related signals of a few kilometers extent would probably have to be at least 0.6°C warmer or colder than the undisturbed background to be observed with AVHRR-type sensors.

El Nino

The NOAA-7 AVHRR was a vital tool for monitoring the 1982-1983 El Nino episode in the Pacific Ocean. Developing atypically from past El Ninos (such as in 1956, 1966, 1972), it began during the summer of 1982, nearly six months out of phase, and was significantly stronger than a typical event. As warming developed in the mid-Pacific, west of the dateline, the satellite's measurement of SST augmented a few ship reports of temperatures to provide a near-complete record of the El Nino event. The 1982-1983 El Nino produced

anomalies in warming of the surface waters of 6° to 9°C off the Peru and Ecuador coasts during its peak in early 1983. By summer 1983, the warm waters seemed to lessen their influence on the eastern tropical Pacific. Although rigorous quantitative evidence was diminished in the satellite-derived measurement of SSTs because of atmospheric/stratospheric aerosols from the El Chichon volcano eruptions immediately in advance of the El Nino activity, the surface development and evolution of the warmer water were better portrayed than they had been during previous El Ninos. After a study (1983-1984) of sulfur-rich volcanic eruptions in the tropics and subsequent changes in SSTs in the eastern tropical Pacific over the past 100 years, a significant correlation was observed. The results of this study suggest that the El Chichon eruption of aerosols in the atmosphere played a role in the El Nino event of 1982-1983.

Sea Surface Temperature

Sea surface temperature (SST) studies in the period 1982-1985 focused on two areas of research. These are: development of multi-channel sea surface temperature (MCSST) techniques and the generation of Advanced Very High Resolution Radiometer (AVHRR) data bases.

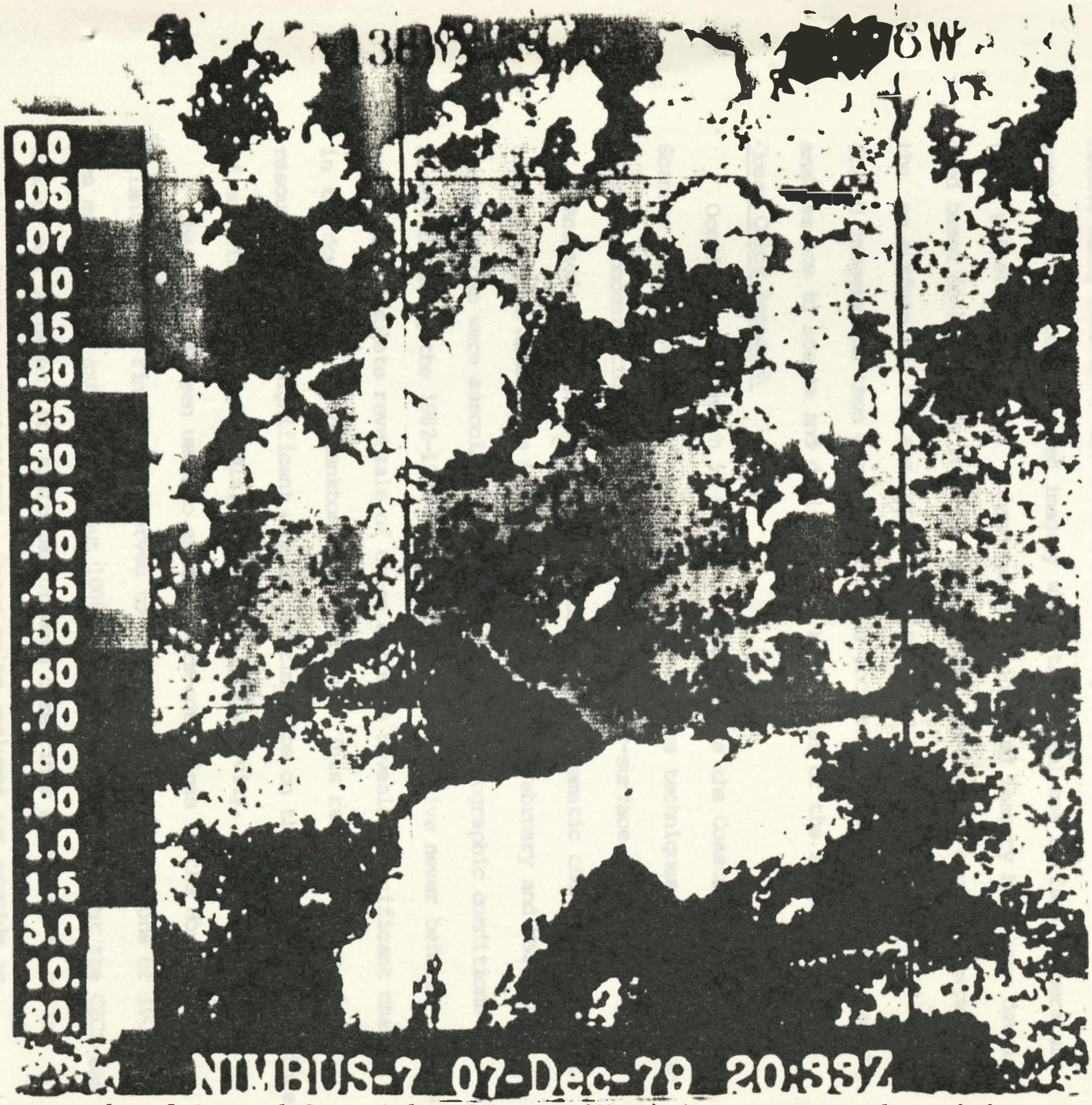
Before 1982, AVHRR data were not readily available to the user for environmental studies. This problem has been partially corrected with the development of the AVHRR experimental data base, which generates imagery of atmospherically-corrected SST patterns (using the MCSST technique) of the open ocean, coastal, estuarine areas, flooding rivers, as well as studies of severe weather phenomena. Data are acquired from the NESDIS mass storage device that contains all the AVHRR data collected by the satellite.

This acquired data is put into the experimental data base. The present configuration of the experimental data base is a disk file which is replaced every 24 hours and put onto an archival magnetic tape which is available for about thirty days before it too is replaced with a new set of data. Information is acquired from either the disk file or 30-day archive tape and processed by computer into imagery. Examples are: (1) Hurricane Lili, the first ever December North Atlantic Hurricane to be recorded by an environmental satellite, (2) and computer-generated contoured analyses of environmental parameters such as temperatures or reflectances. Other remotely-sensed marine parameters include SSTs of the Sargasso Sea and the Persian Gulf, and turbidity and SST patterns in the Chesapeake Bay. This imagery can be acquired within 48 hours of the time the data have been saved on the mass storage device.

Nighttime Sea Fog Detection

The occurrence of sea fog in the New England coastal area causes poor visibility which affects helicopter flights to and from offshore oil rigs, recreational and commercial boating, and flight operations at coastal airports. Due to the lack of conventional surface reports in this area and the need for frequent interval reports, geostationary satellites are being used to gather information. The primary instrument on these satellites, the Visible Infrared Spin Scan Radiometer (VISSR), provides observations of the Earth in digital form every 30 minutes, continuously, to operational users. The VISSR produces visible (1-km resolution) and infrared (8-km resolution) imagery which is available as hard-copy images or digital data on magnetic tape.

Using the geostationary satellite imagery, daytime detection of sea fog has been successful. Visible imagery shows good contrast between the sea fog cloud and the surrounding water, allowing the boundaries of the sea fog to be easily viewed.



An example of Coastal Zone Color Scanner (CZCS) imagery over planned deep seabed mining sites. The area is centered at 137°W and 13°N. Chlorophyll ranges from 0.05-1.1 mg/m^3. White areas are clouds. Note frontal zone peak at 138°W. The imagery illustrates chlorophyll patchiness and frontal conditions in this part of the tropical Pacific.

Nighttime detection of sea fog has been limited by the infrared imagery which displays a small thermal contrast for locating sea fog boundaries. A recent study concluded that nocturnal sea fog boundaries can be located on specially enhanced infrared imagery where the normal sea surface temperature (SST) patterns are known. Enhancements of infrared imagery have been developed based on known SSTs in order to increase the thermal contrast between the ea surface and the sea fog. Applying these enhancements to cloudless infrared imagery and then comparing this to nocturnal enhanced infrared imagery, enables one to locate and delineate the boundaries of the sea fog at night.

Ocean Color Research

Ocean color research is continuing to utilize the Coastal Zone Color Scanner (CZCS) on Nimbus-7 to develop quantitative techniques in the measurement of concentrations of plankton and other near-surface material.

Analysis made in 1984 of CZCS data revealed dramatic changes of pigment concentrations around the Galapagos Islands during February and March 1983. These changes were associated with the unusual oceanographic conditions observed during the 1982-1983 El Nino from a perspective never before possible. Complete reversals of ocean currents revealed significant changes in the downstream phytoplankton distributions. This redistribution of food resource may have significant causal relationships on the reproductive failure of sea birds, marine mammals, and primary productivity.

The CZCS has been used to examine warm-core rings in the Northwest Atlantic. These rings are observed to have horizontal dimensions of 100-200 kms and vertical extents of about 1000 meters. Study shows that the CZCS can follow and document life histories of warm core rings according to their surface pigment concentrations. Ocean color analyses can provide an indication of the mixing between rings and slope and shelf waters and for study of ecosystems impacted by these rings.