NATIONAL OCEANOGRAPHIC PROGRAM

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PREFACE

The National Oceanographic Program—A Perspective

The ocean has long had special significance to the people of the United States. Since colonial days we have both profited and suffered from our intimate relationship with the sea. Today, we face the sea along a general coastline of 12,500 miles. Our cities, villages and farms have experienced the destructive forces of hurricanes and storm-generated waves. Our mariners have known the fury of troubled seas. Yet we have grown and prospered in many ways because of the sea. Quite early, our proximity to the ocean encouraged private enterprise to develop and expand industries such as fishing and shipbuilding. Opportunities for trade stimulated the growth of a merchant marine, which eventually projected U.S. maritime power throughout the world.

From the first days of the Republic, American industry looked to the Federal Government for protection and assistance in these endeavors. Thus, among its early acts, the Congress established in 1790 a sea-going Revenue Service (later the Coast Guard) to enforce United States laws at sea. In 1798, it authorized a navy, to defend our coasts and our ocean commerce, and a marine hospital service (later to become the Public Health Service) to provide medical care for merchant seamen. The Coast Survey (later the Coast and Geodetic Survey) was established in 1807 to improve navigation in coastal waters. As the nation became more involved in the marine environment, the Federal Government assumed additional responsibilities in the national interest: to dredge harbors and navigable channels (U.S. Army Corps of Engineers, 1824); to protect and improve the management of our fishery resources (Department of State, 1828; and the U.S. Fish Commission, 1871—later, the Bureau of Commercial Fisheries and the Bureau of Sport Fisheries and Wildlife); to provide charting and routing services to Naval and merchant ships (the Depot of Charts and Instruments—1830, now the Naval Oceanographic Office). In assuming these responsibilities, the government sought practical solutions to practical problems, principally in the fields of navigation and fisheries.

In the nineteenth century, the scientific community emerged to give new direction to our efforts at sea. Here, as in Europe, naturalists with an interest in the marine environment were essentially landbound, working from small boats in shallow waters and along beaches. A few men, however, sought a broader understanding of the ocean's processes, boundaries, and contents. Their research required the collection of data over broad ocean areas, but only the government was in a position to provide the facilities for such oceanwide studies. Throughout most of the century, the Navy, the Coast and Geodetic Survey, and the Smithsonian Institution (founded in 1846) encouraged scientists to accompany government sponsored expeditions. The Navy, through the efforts of Matthew Fontaine Maury, requested mariners to make systematic observations of winds and currents from merchant vessels so that forecasts could be made of sailing conditions in distant oceans.

Thus, research and data collection—insofar as it was relevant to an agency's mission—was encouraged and often supported by the Federal Government. By the early 1870s, for example, our New England fisheries clearly required a scientific basis for management. But few scientists were then available in government to provide this support. Fortunately, the Smithsonian Institution—the only government agency at that time with a charter permitting it to conduct basic research—was able to encourage naturalists to perform research for the U.S. Fish Commission. Spencer F. Baird, Assistant Secretary of the Smithsonian, became first Commissioner of Fish and Fisheries (1871).

By the turn of the century, working relationships with the scientific community—small as it then was—had been established by all agencies with ocean-oriented missions. Industry, too, had a stake in the modest but active programs of these agencies, especially the fishing and shipping interests. Furthermore, strong international ties had been established between marine scientists in the United States and Europe.

Following World War I, the Navy, the Coast Guard, the Fish Commission, and the Coast and Geodetic Survey continued their essentially descriptive work at sea. Nevertheless, there was concern on the part of the recently established National Research Council (NRC) of the National Academy of Sciences (NAS) that the marine sciences in the United States lacked sufficient scientific leadership. In contrast to Europe, where marine scientists enjoyed wide government support and recognition, the United States had few institutional facilities for training and developing leadership in oceanography. Recognizing this need, the National Research Council established its first Committee on Oceanography (NASCO), in 1927, to consider the role of the United States in a worldwide program of oceanographic research. The Committee report had a major impact upon the scientific community and was instrumental in obtaining—from philanthropic sources—funds for endowing institutions on both coasts, and for constructing a ship and a few shore facilities.

During the 1930's, such oceanographic laboratories as the Scripps Institution of Oceanography and the Woods Hole Oceanographic Institution became the centers of scientific excellence which were to serve the United States so well during World War II. Then, for the first time, investigations were pressed by the Federal Government in an effort to apply oceanography to the solution of urgent defense problems. The small nucleus of oceanographers trained in the 1930's was augmented by scientists from other disciplines, many of whom remained associated with the marine sciences after the war.

Following World War II, oceanographic programs in the Office of Naval Research, the Naval Hydrographic Office (now the Naval Oceanographic Office), the Bureau of Ships, the Bureau of Commercial Fisheries, and the newly established Atomic Energy Commission expanded to meet the growing problems of the marine environment. At the same time, the government continued to support oceanographic research at universities and research institutions. By 1949, the National Academy of Sciences again became concerned over the relative growth of the marine sciences in the United States. A second Committee on Oceanography was appointed. Rather than urge a greatly expanded effort, the Academy's 1951 report stressed the necessity of regaining the balanced program of basic research that had characterized oceanography in the years before the war. Coming as it did in the first year of the Korean conflict, the report failed to stimulate effective action. However, in 1951, the National Science Foundation (NSF) made its first grant in the field of oceanography, and by 1954 a significant percentage of the grants in NSF's Environmental Biology and Earth Sciences Programs had been made in oceanography.

A third NAS/NRC Committee on Oceanography was established in 1957. At that time the U.S. was spending less than $35 million annually for studies of the ocean out of a national basic research budget of well over $1 billion. Three Federal agencies with oceanographic programs (Atomic Energy Commission, Bureau of Commercial Fisheries, and the Office of Naval Research) requested the Committee to identify the national requirements for oceanographic research and to propose a ten-year program for their accomplishment. It was apparent from the Academy's deliberations that the traditional concept of "oceanography" as basic science had changed since the 1930's. While emphasizing oceanography as an interdisciplinary science, the NASCO panels addressed

themselves to such subjects as marine resource development, ocean engineering, and man's effect upon the ocean environment—all very "practical" concerns directly related to the national interest. Programs that had never been recognized as "oceanography" in its classical sense were considered: marine biology; water pollution control; shellfish sanitation; recreation; and coastal and deep ocean engineering. "Oceanography" had been broadened to include many aspects of man's activities in or on the ocean.

In considering the problems identified by its panels, the Academy was concerned, on the one hand, with an assessment of the needs of the field, and on the other, with such limitations on its development as the rate at which ships and facilities could be built and new manpower trained. The report concluded that: "Action on a scale appreciably less than that recommended will jeopardize the position of oceanography in the United States relative to the position of the sciences in other major nations, thereby accentuating serious military and political dangers, and placing the nation at a disadvantage in the future use of the resources of the sea."

When released in 1959, the first chapters of the 12-volume report catalyzed action by both the executive and the legislative branches of government. In the Senate, a resolution concurring in the NASCO recommendations passed unanimously. A Subcommittee on Oceanography was established by the House Merchant Marine and Fisheries Committee. Legislation was enacted to strengthen the marine sciences by removing certain statutory limitations upon the Coast Guard, Coast and Geodetic Survey, and Geological Survey, enabling these agencies to participate in broader oceanographic work. In the executive branch, the recommendations were considered by the President's Science Advisory Committee (PSAC), which had earlier concluded that oceanography was a neglected field requiring additional emphasis. The PSAC endorsed the objectives of the report and commended it for action to the newly established Federal Council for Science and Technology.

At the Council's request, the President's Science Advisor established a Subcommittee on Oceanography in mid-1959, with representatives from the Departments of Defense, Interior, and Commerce, the Atomic Energy Commission, the National Science Foundation, and the Bureau of the Budget.

The Subcommittee on Oceanography, in turn, examined ways by which an overall and integrated national program in oceanography might be initiated by the Federal Government. The Subcommittee's report recognized that "the resources of the sea are of interest to every major department and agency of the government, and that the strengthening of the marine sciences poses one of the most difficult problems of coordination in the organization of science in government." It concluded that "it is evident that procedures for formulating programs within the several agencies are well established but that there are deficiencies in coordination between agencies, in providing adequate funding, and in the mechanisms for carrying out a coordinated national program." Among its general recommendations were:

1. That as a national objective the Federal Government undertake a program for a substantial and orderly expansion of effort in the field of oceanography.

2. That this expansion of the national effort...be planned in general conformity with the NASCO recommendations as modified in the Subcommittee's report.

3. That full advantage be taken of existing Federal programs which can support training, education, and basic research in oceanography.

4. That professional oceanographers and interested scientific and research institutions take vigorous action to recruit scientists and organize educational programs.

5. That the national program in oceanographic research and surveys be planned and conducted taking maximum advantage of the mutual benefits to be derived from international cooperation.

The Subcommittee went on to make the following specific recommendations:

1. That a permanent interagency committee be established by the Federal Council to implement, coordinate, and review a national program in oceanography.

2. That the Federal agencies concerned develop ten-year plans for expansion of their existing programs in oceanography consistent with the national objective.

In late 1959 the Federal Council for Science and Technology accepted and endorsed the recommendations of the Subcommittee. Oceanography was recognized as an important field requiring additional emphasis in the national interest. The Interagency Committee on Oceanography (ICO) was established in February 1960 as a permanent committee, charged to provide the essential direction and coordination by preparing annually a National Oceanographic Program, incorporating the Committee's judgement as to balance and emphasis in terms of both long-range scientific needs and requirements of government agencies. Represented on the ICO were those Federal agencies with statutory responsibilities involving the marine environment, and observers from NASCO and the Bureau of the Budget.

Ten-year plans were prepared by each of the member agencies and synthesized into a long-range national oceanographic plan for the period 1963-1972 (*Oceanography, The Ten Years Ahead,* ICO Pamphlet No. 10). Approved by the President in 1963, this plan (1) addressed itself to oceanographic problems of national interest, and (2) outlined the goals toward which a national oceanographic program must be directed to meet national needs. In effect, the plan provides a means by which Federal, academic, and industrial members of the oceanographic community can look ahead together by providing a perspective in which they can see their various programs in relation to each other and to the national goals they support.

In developing its annual programs since 1964, ICO has been guided by, but not bound to, the long-range plan. The annual program is based on the recommendations and findings of seven special ICO panels* which reflect skills and competence found in the agencies and provide a means for expression of many points of view. In planning the program, panel members identify technical needs in various areas, devise programs and measures to meet these needs, identify desirable allocations of technical effort among the agencies, and suggest the assignment of technical leadership.

The Interagency Committee on Oceanography reviews these panel recommendations and findings to assure an appropriate division of technical effort among the agencies as well as a meaningful balance of oceanographic effort. It examines the adequacy of the overall program and the manpower base required for its implementation. Finally, it recommends policies to improve the quality and vigor of the national effort.

The Committee's recommended program is in turn reviewed by the staff and consultants of the Office of Science and Technology, which forwards its comments to the Federal Council for Science and Technology for final review and approval.

The recommended program is then integrated into the agency programs through normal agency channels. The agencies themselves retain responsibility for accepting or rejecting specific projects, for developing or conducting their own annual programs, and for defending them individually before Congress.

This process helps reduce competition for such resources as skilled manpower and funds and promotes their most effective use, encourages centralized planning and joint cooperative enterprises, promotes communication among key members of the oceanographic community, fosters a realistic and effective balance of effort among participating agencies and institutions, prevents needless duplication of work, and makes possible an orderly progression toward goals important to the national interest.

*Research, Ocean Engineering, Surveys, Instrumentation and Facilities, Ships, Manpower, International Programs.

PART ONE

National Oceanographic Program

I. Introduction
II. Proposed FY 1967 Program

I. INTRODUCTION

The National Oceanographic Program for Fiscal Year 1967 represents the plans of nine Federal departments and agencies, coordinated through ICO panels on Research, Surveys, Ocean Engineering, International Programs, Ships, Instrumentation and Facilities, and Manpower and Training. This program document is designed to inform the executive branch, the Congress, and the scientific and industrial communities of those efforts and resources needed in FY 1967 to advance this nation's exploration and exploitation of the ocean.

A. Oceanography and the National Interest

In developing this program, the Interagency Committee on Oceanography recognizes that a truly national program must be responsive to the national interest, which with respect to the ocean sciences and technology, is a collective expression of many regional, State, local, institutional, industrial and individual interests, each concerned in some way with problems and opportunities in the marine environment.

To what extent is oceanography actually related to the national interest?

1. Basic Science

Basic, fundamental knowledge of the ocean—its boundaries, processes and contents—is needed to solve many of the practical problems of concern to the nation. Federal agencies specifically charged with attacking these problems recognize that continued pursuit of basic research—with no specific application in mind—is required to support their long-range objectives. Much of the oceanographic research sponsored by the Federal Government in universities and institutions is of this nature. Such research seeks answers to fundamental scientific questions and, for the most part, is not concerned with whether this knowledge is of immediate practical interest. This work is justified because: (1) a deeper understanding of fundamental problems inevitably leads to new or refined solutions to practical problems and can result in new and unexpected practical benefits; (2) it contributes to our national cultural resources; and (3) it supports the education of our young people. The marine environment is so imperfectly understood that oceanographic research must be further strengthened to close many broad gaps in our understanding and to support adequate scientific and technical leadership in the ocean sciences and ocean engineering.

2. National Defense

The ocean, in all its dimensions—from surface to sea floor—is a potential arena for international conflict. In the past, naval operations were conducted at or near its surface. In recent years, however, technology has developed vehicles and weapons for operations at greater depths; additional millions of cubic miles of ocean have become available for military purposes. Submarines armed with ballistic missiles can use the ocean's cloak of concealment to strike any target on earth. In the near future, naval warfare may be extended to the seabed, as nations intensify their competition for resources and strategic positions on the ocean floor. These vast areas beyond the continental shelves, are now, by international law, accessible to any nation with the technology to establish and maintain sovereignty over its seabed. It is therefore urgent that the United States develop a military capability to operate—offensively and defensively—throughout the total marine environment. Oceanographic research, systematic ocean surveys, and ocean engineering are needed to broaden our knowledge of this complex environment, and so permit the development by government and industry of systems needed to accomplish present and future defense missions.

3. Resource Management—World Ocean

The resource potential of the ocean has long been recognized by the maritime nations of the world. Indeed, the present exploration and exploitation of the sea by the United States is, to a large extent, motivated by a realization that resources from the sea may someday be essential to support a growing population and expanding

economy. The U.S. is concerned, too, over the plight of less fortunate nations. Today, more than two-thirds of the people of the world suffer from protein-deficiency diseases—a problem that could be alleviated through a wider distribution of food from the sea. However, as we take more fish from the sea, we must learn more about their distribution, abundance, and behavior, so that the United States—in cooperation with other fishing nations—can insure a maximum sustainable yield of these fishery resources for generations to come. To meet these, and future challenges, the Federal Government must strengthen our fishing industry. It is doing so by strongly supporting oceanographic and marketing research and encouraging the development of new technology to improve the efficiency of our fishing methods and the processing of food products from the sea.

Minerals are being recovered from the ocean in many areas throughout the world. In the United States, the principal offshore mineral resources now being exploited are petroleum, natural gas, magnesium and sulphur. Large investments by private industry are being made to extend drilling into deeper waters of the Gulf of Mexico and off the west coast. Geophysical exploration has intensified off the Atlantic and Pacific coasts, with Federal agencies contributing data from prior surveys of these areas. The incentives for exploitation are so compelling and competition so keen that private enterprise can be expected to maintain leadership in the exploration for oil and sulphur. There are, however, other potentially valuable marine minerals that are presently unexploited by industry, because (1) uncertainties and imperfections in Federal and State laws and leasing procedures deter potential undersea prospectors; (2) inadequate prediction of weather and waves has been responsible for inefficiency in operation, as well as serious loss of life and equipment to those who are engaged in off-shore exploitation of resources; and (3) the processing and recovery of these minerals is not yet economically feasible. Detailed surveys and oceanographic research must precede any future industrial exploitation. The government's role in fostering this pioneering effort, by providing information and making Federal technology available, can be considered an essential investment toward that time when the scarcity of materials presently mined ashore will focus this country's industrial development on mineral sources in the ocean. The first areas to be explored intensively will be our own continental shelves. The potential of the shelves will be discussed later in this report.

4. Resource Management—Domestic Waters

The population of the United States will double by the end of this century. As the nation grows and prospers, urban population centers and possibly industrial complexes will expand along our coasts and into our domestic waters. Competition for marine resources that Americans hold in common will intensify: for fresh water, for waste disposal areas, for recreation, and for seafood. Research and engineering are needed to conserve these valuable resources in the public interest, and to assure their wise management at the Federal, State, and local levels of government. This effort reflects a growing national concern over man's adverse modification of his environment through pollution of the apparently unlimited expanse of fresh air; of vast systems of lakes, rivers, and streams; and of the ocean, through runoff or direct disposal of industrial wastes, sewage, and low-level radioactive materials. Confronted with the long-term consequences of this alteration of the marine environment—the potential threat to public health and the possible degradation of a resource treasured for its beauty alone—Federal and State agencies have embarked upon a broad, coordinated effort to manage and conserve the wealth of the marine environment.

5. Protection of Life and Property
Maritime Safety

Weather and climate on land are inextricably linked to the sea. Droughts, floods, and blizzards, thousands of miles from the sea, are generated as part of a complex process related to meteorological conditions near the surface of the ocean. With an increased understanding of large-scale interactions between the ocean and atmosphere, long-range weather forecasting can be improved, resulting in benefits to every citizen, from farmer and industrialist, to office worker and school child.

Each year, the U.S. alone suffers hundreds of millions of dollars in damage to homes, factories, farms, beaches, harbors, and ships, from hurricanes, sea-ice, fog, and earthquake generated or storm-propelled waves. It is an important objective of oceanographic research to achieve a better understanding of these phenomena, so that better prediction methods can be developed. Research and engineering may eventually lead to ways of modifying the effects of these forces of nature.

Despite man's long experience as a shipbuilder and navigator, the efficiency and safety of maritime commerce remains a major international problem. Exclusive of war years, an average of 270 ships registered with Lloyd's are lost every year. In addition, hundreds of collisions, fires, and other disasters occur at sea, many in waters patrolled by the U.S. Coast Guard. Safe operations at sea can be enhanced by improved weather and sea state forecasting, more accurate and reliable navigation systems, and better nautical charts and atlases. These capabilities will also improve the efficiency of our ocean-going merchant fleet.

Although air-transportation will play an ever increasing role in transoceanic commerce, the large displacement ship will continue to be a more economical and efficient means of transporting bulk cargo. An important objective of ocean research and marine engineering is to support the U.S. Merchant Marine by the best of American science and technology. Thus our improved understanding of the ocean can be translated not only into more efficiently designed ships, but also into more effective routing of these new ships, for fast freight delivery and reliable passenger service.

B. National Goals in Oceanography

The broad national objective in oceanography:

> *To comprehend the world ocean, its boundaries, its properties, and its processes, and to exploit this comprehension in the public interest, in enhancement of our security, our culture, our international posture, and our economic growth.*

In support of this objective, five subordinate goals are identifiable, each reflecting specific responsibilities the Federal Government has assumed in the national interest. In the program proposed for Fiscal Year 1967, each goal has been further defined to present more specific objectives. It must be remembered that the goals and specific objectives listed below are interdependent; furthering of one inevitably enhances the attainment of one or more other goals:

1. Strengthen Basic Science

a. Encourage and support investigators at academic institutions and within the Federal agencies to enlarge our present knowledge of the ocean by conducting *basic* research to achieve the following scientific objectives:

(1) Describe the distribution of physical and chemical properties of the ocean with a view toward improving our understanding the dynamic processes which affect this distribution.

(2) Determine the interrelationships of the ocean and atmosphere, and broaden knowledge of the mechanisms and processes affecting these relationships.

(3) Determine the distribution, kind and adaptation of the living population of the sea in an effort to understand more fully the interrelationships of marine organisms to the physical and chemical properties of the sea.

(4) Describe the sea floor with a view toward increasing knowledge of its long-term and short-term evolution including the topography, geophysical nature and subsurface structure and particularly the sea floor's relation to the surrounding land masses.

b. Plan cooperative basic research programs in the above areas that are either outside the mission of a single agency or beyond the capabilities of any academic institution.

c. Expand the manpower base in oceanography by awarding scholarships and graduate fellowships.

d. Foster the interchange of information among marine scientists in the United States and in other nations, and encourage international participation in oceanographic programs of mutual interest.

2. Improve National Defense

a. Advance knowledge of ocean, coastal, and seabed areas to increase the effectiveness of naval

operations required to fulfill the assigned missions of the Department of Defense.

b. Provide direct support to naval systems development and ship and equipment design by solving specific, immediate and long-range scientific and engineering problems associated with the marine environment.

c. Improve the detection, location, identification and verification of underground and underwater nuclear explosions.

3. Manage Resources in the World Ocean*

a. Living Resources

(1) Locate new productive fishing areas (for species presently in demand)

(2) Identify and locate promising fishery resources (for species presently unexploited and not in demand).

(3) Improve fish harvesting operations and techniques, including aquaculture.

(4) Forecast the abundance and distribution of fish populations.

(5) Provide scientific management of fisheries through:

(a) Cooperative programs of Federal and State Governments.

(b) Industrial cooperation.

(c) International cooperative programs.

b. Mineral Resources

(1) Chart and map topographical and geological features of the sea bottom.

(2) Locate and identify potentially useful mineral and fuel deposits.

(3) Develop techniques for recovery and processing of commercially valuable minerals.

4. Manage Resources in Domestic Waters

a. Safeguard Public Health

(1) Monitor and determine the distribution of pollutants in the marine environment, and their effects upon harvestable organisms and man.

(2) Develop methods to control pollution in estuarine and nearshore areas which may result from:

(a) Sewage effluent

(b) Industrial wastes

(c) Pesticides

(d) Thermal effects

(3) Monitor potential sources of radioactive contaminants to the sea; understand the processes which control the distribution of these contaminants, their uptake by marine organisms, and their ultimate effects upon man.

(4) Determine the public health suitability of foods derived from the ocean and the effects of marine organisms and their byproducts upon man.

(5) Discover and extract pharmaceuticals from seawater and marine organisms.

b. Conserve Marine Resources Held in Common

(1) Protect fisheries and recreational uses of the nearshore environment against degradation by pollution while assuring legitimate use of the ocean for waste disposal.

(2) Improve recreational opportunities by developing beaches, small boat harbors, and other facilities.

(3) Protect beaches and waterways against damage by erosion or deposition.

(4) Develop new beach areas and extend coastlines for industrial, recreational, and aesthetic purposes.

5. Protect Life and Property Ashore; Insure the Safety and Efficiency of Operations at Sea

a. Protect Life and Property Ashore

(1) Improve long-range weather and wave forecasting through studies of ocean-atmosphere interaction.

(2) Develop methods for dissipating hazards caused by ocean-atmosphere phenomena such as hurricanes, storm-generated waves, fog and ice.

(3) Protect nearshore environment and man-made structures from land-sea interaction phenomena (*e.g.*, beach erosion, silting, *etc.*).

(4) Develop techniques for predicting the paths of earthquake-generated waves (tsunamis) and systems for warning coastal populations.

b. Improve Safety and Efficiency of Operations at Sea

(1) Improve forecasting of waves, tides, currents and sea-ice drift (and dissemination of this environmental information) to route ships along minimum time paths and to lower storm losses.

(2) Develop new, more efficient and economical ship designs based upon improved knowledge

*Includes resources in and on the continental shelves as well as the deep ocean.

of such oceanographic phenomena as sea-surface waves.

(3) Improve navigation techniques and systems (based upon more detailed knowledge of the ocean) to reduce damage from collisions and strandings.

(4) Improve nautical charting techniques.

(5) Develop techniques to prevent ship and port facility damage from fouling and boring organisms (based upon an improved understanding of the life histories, behavior and physiology of these organisms).

(6) Improve harbor construction and sea-terminal operations (based upon better knowledge of oceanographic conditions).

C. Program to Achieve National Goals

To help achieve the above goals, a national program of ocean exploration and development is envisioned, requiring the participation of Federal, State, and local governments, industry, universities, and research institutions. This program consists of three distinct efforts: Scientific Exploration—the Oceanographic Research Effort; Geographical Exploration—the Oceanographic Survey Effort; and Maritime Development—the Ocean Engineering Effort.

1. Scientific Exploration

The scientist-explorer and the oceanographic engineer seek to apply such disciplines as chemistry, biology, geology, physics, geophysics, and mathematics to achieve a better understanding of the ocean's contents, boundaries, and processes. To gain this understanding, he observes and measures ocean phenomena: the motion of its waters; the rocks and sediments of its basins; the ways of life in the sea. He seeks to interpret; to discover relationships underlying observed phenomena. He asks, "why?", "how?". His explorations result in new knowledge about the world in which we live.

Some scientists seek fundamental knowledge, others explore the ocean to help solve problems important to our security, welfare, and economic well-being. The oceanographic programs of the National Science Foundation, for example, support the first type of basic, discipline-oriented research. Other ICO member agencies conduct programs more clearly directed toward scientific and non-scientific goals of society. These "mission" or "problem" oriented agencies, however, do support some basic research and consider it essential for future applications. Such research is performed to obtain knowledge, not for its own sake, but rather to fulfill the agencies' missions.

2. Geographical Exploration

This is a broad ocean reconnaissance—a 20th century extension of a worldwide effort begun five centuries ago, when Renaissance explorers first began the systematic description of the ocean's uncharted boundaries. The objective today is to survey the world ocean: at the air-sea interface; throughout the water column; and across the ocean floor. In contrast to scientific exploration—where oceanographers seek to understand relationships between observed phenomena—the geographic investigator is concerned primarily with the, "what?", "where?", and "when?" of the ocean's features. His is an ocean-wide, descriptive effort, with far-reaching economic and political implications.

Geographical exploration serves two important purposes: first, to collect data required by agencies to fulfill statutory missions (*i.e.*, national defense, navigation, pollution control, resource development, and ocean engineering), and second, to provide an archive of exploratory information needed by the research oceanographer and industry.

3. Maritime Development

In previous years only two engineering programs (one conducted by the Army Corps of Engineers and the other by the Bureau of Mines), were reported in the National Oceanographic Program, and both of these were considered under the broad category of research. In recent years, however, ocean technology has received new impetus. The search for the ill-fated submarine, THRESHER, focused national attention on our technological limitations for penetrating and working in the ocean depths. Recognizing a need for this capability, the Navy in 1964 inaugurated the Deep Submergence Systems Project, in which the resources of government and industry were mobilized in a major ocean

engineering effort. Industry, too, has intensified its efforts. Offshore deposits of commercially valuable minerals await industrial development. Commercial fishermen seek more efficient ways of harvesting the huge, unexploited stocks of high protein food in the sea. Shipping interests want ships and vehicles better adapted to the ocean environment to expedite our ocean-going commerce. Concerned over water pollution and threats to our recreation resources, Federal, State, and local governments look to ocean engineering for solutions to these urgent problems. Such undersea construction as the building of offshore towers and other sea-floor structures has also stimulated work in this emerging field.

In response to these challenges, new tools and techniques must be developed for work in the sea. Professional engineers must be trained to spearhead new programs. Moreover, this effort—particularly within the government—must be given added direction and purpose.

These factors have compelled the Interagency Committee on Oceanography to identify ocean engineering as a separate category in the National Oceanographic Program for fiscal year 1967. Funding tables in this publication for Fiscal Years 1965 and 1966 also identify ocean engineering for purposes of comparison. Nevertheless, the program as a whole shows a marked increase over the past years, much of it due to Navy's Deep Submergence Systems Project.

D. Progress Toward National Goals

Over the past five years, the nation has strived to achieve the national goals in oceanography by expanding its total capability. As this capability has grown, it has been put to productive use. Quite naturally, material capabilities—new ships, modern laboratories and advanced oceanographic tools—were among the first concrete accomplishments of the program.

Exciting scientific accomplishments have resulted from application of the new capabilities. These accomplishments are revealed in the growing body of oceanographic literature, and—in some areas—in practical application to the missions of sponsoring agencies. A recapitulation of the past five years' progress will be published this year in the NASCO report, *Achievements and Opportunities in Oceanography*. Examples of recent accomplishments in the National Oceanographic Program are summarized below.

1. New Capabilities Available to the National Program

a. *Research Vessels.* In the past calendar year, seven new or converted research vessels joined the oceanographic fleet to bring the total to 113, including 37 Coast Guard cutters and ice breakers with oceanographic capability. Significantly, four of the new vessels are operating primarily in support of biological programs: two (DAVID STARR JORDAN and UNDAUNTED) for the Bureau of Commercial Fisheries; one (PHYKOS) for the Smithsonian Institution (its first ship in this century); and one (ALPHA HELIX) sponsored by the National Science Foundation. These additions to the research fleet provide needed capabilities to a field that has long suffered from the lack of adequate sea-going platforms.

b. *Survey Ships.* In calendar year 1965, the Navy's new ocean survey vessel, SILAS BENT, joined the fleet to meet an acute shortage of vessels for oceanwide descriptive work.

c. *Undersea Research Vehicles.*[1] The past year was characterized by mounting interest in undersea research vehicles (URVs). Some oceanographers had opportunities to use and evaluate vehicles chartered or leased from private industry. The Cousteau DIVING SAUCER was chartered by the Scripps Institution of Oceanography and made 175 dives in six months of cooperative effort with Navy west coast laboratories. ASHERAH was chartered by the Bureau of Commercial Fisheries for a month-long biological program off Hawaii. Enthusiastic reports indicate these new tools may well revolutionize scientific exploration of the deep ocean. Highlighting the Navy's effort in the URV field was deployment of the ONR-supported, WHOI-operated, ALVIN, to the Bahamas during the summer of 1965. Operating in this area it penetrated to a depth of 6000 feet. The world's deepest diving true submarine, the ALUMINAUT, was tested and put into operation during 1965. In its early trials ALUMINAUT demonstrated its exceptional potential for work in the deep ocean.

d. *Other Platforms.* Also adding to our oceanographic capability are new data collection plat-

[1]For detailed information on URVs, see ICO Pamphlet No. 18, *Undersea Vehicles for Oceanography*

forms, such as Navy's recently completed SPAR, a FLIP-type platform for acoustics research, and an advanced buoy developed for ONR. The latter is capable of telemetering data at 100-bits per second and can remain unattended up to one year. Other platforms represent different approaches to data collection and observation. Five aircraft are currently supporting oceanographic work at the Naval Oceanographic Office. In Antarctica, NSF used a specially-designed observation chamber to make, for the first time, simultaneous observations and recordings on tape and film of the activities of the Weddell seal under sea-ice.

e. *Instrumentation.* New tools for measurements and observation are also contributing to our oceanographic capability. However, instrumentation is not moving ahead as rapidly as many would wish, since the lack of hard specifications and poor reliability continue to be major problems. Nevertheless, accomplishments such as NAVOCEANO's and ESSA's shipboard oceanographic computers and multisensor systems represent major advances in the field. Progress has been made in precise oceanwide navigation, a problem that has long plagued the oceanographer. Oceanographic institutions working with the Navy have developed an effective navigation system which utilizes transmissions from several Navy experimental very low frequency navigation stations. Equipment for receiving fixes from navigation satellites is also being installed on some oceanographic ships. VLF and satellite systems are particularly useful in remote areas of the world, presently beyond the coverage of LORAN C networks.

f. *Data and Information Systems.* Oceanographic research requires a large amount of information on current programs. The Smithsonian Institution's Science Information Exchange has advised and assisted ICO members in acquiring information helpful in managing their programs.

National Oceanographic Data Center (NODC) reimbursable requests for data and information services nearly tripled from 1962 to 1965, reflecting the increased requirements and confidence of the oceanographic community. Moreover, NODC has fostered an expanded international exchange of data through its operation of World Data Center A. In 1965 the Center exchanged data with organizations in some 40 countries. This included direct contact with agencies in 29 different countries and indirect dealing with four international groups. NODC has made progress in developing systems for processing physical, biological, and geological data. Some preliminary work has also been accomplished in developing an archive system for chemical data. Although it will require a further effort to clear up the total oceanographic data backlog, NODC has made a major assault on oceanographic station and bathythermograph (BT) data. It has the largest collection of these two types of data in the world, with an archive of 300,000 stations (6 million discrete observations) and more than a million BT prints in its analog data file.

In an effort to improve the handling of biological specimens, an oceanographic sorting center has been established at the Smithsonian Institution. The Smithsonian Oceanographic Sorting Center (SOSC) has received, processed, and shipped over five million specimens from biological collections obtained on international expeditions from the U.S. Antarctic Research Program and from other marine collections of the Smithsonian, Federal, and private agencies. The specimens are preserved, properly labeled, given general identification, packaged, and sent to scientists around the world for research on the populations, distributions, and interrelationships of marine organisms.

g. *Laboratories.* Over the past calendar year, new laboratories have gone into operation to expand further the nation's oceanographic capability, especially in the field of biology and fisheries research. For example, the Bureau of Commercial Fisheries laboratory on the campus of the University of California at San Diego is believed to be one of the finest fishery research centers in the world. BCF's new lab at Beaufort, North Carolina, will provide unique facilities for studying the effects of radioactive material on aquatic life. At Seattle, another new lab has opened to increase the Bureau's capability for solving problems connected with fisheries in the Pacific Northwest. The recently dedicated biological laboratory adjacent to the University of Miami's Marine Laboratory will serve as a base of operations for two Bureau research vessels investigating the vast fishery resources of the Tropical Atlantic (particularly the tuna) and the oceanographic factors affecting their distribution.

h. *Manpower.* Before the recent acceleration of oceanographic effort, recruiting of oceanographers was just barely adequate to meet the requirements of existing programs. It became obvious that additional scientists were needed to support the increased effort. As with any other multi-disciplinary area of research, this required training of students at the universities and attracting into oceanography chemists, physicists, geologists, biologists, mathematicians, engineers, and members of other professions. At that time, seven years ago, laboratory and teaching facilities at the universities were inadequate to accommodate graduate students and staff.

Since then, existing facilities have been upgraded, and new ones built to permit the institutions to enlarge both their staffs and their graduate enrollments. The National Science Foundation and the Office of Naval Research have been in the forefront of this effort.

2. Scientific Accomplishments Resulting from Use of New Capabilities

Broad areas of accomplishment are given below as examples of recent oceanographic progress. They are, however, only a few of those currently being documented by the Interagency Committee on Oceanography.

a. We have significantly increased our knowledge of the distribution, kinds and adaptations of the living population of the sea. We now know more about the relationship of marine organisms to each other and to the physical and chemical properties of the sea.

(1) One of the most exciting recent advances in comprehending food chains within the sea is the discovery that organic material, instead of being in uniform suspension in the ocean, is frequently found in the form of conglomerates. These particles, described as 'snow flakes,' are composed of phytoplankton and bacteria adhering to non-living organic material suspended in the water. In the past, the marine animal food chain was considered a one-way process, in which life was derived mainly from living matter, with small organisms being eaten by larger ones. The phytoplankton, which assimilate the inorganic compounds through photosynthesis, were thought to be the primary source of food for the zooplankton, which were in turn devoured by larger animals, and so on. However, some scientists reasoned that this long-held belief was inadequate to explain nutrient utilization in the sea and that there must be another basic food supply in the ocean. The breakthrough came recently when government-supported investigators working at Woods Hole demonstrated that organic particles could be reconstituted from the organic material dissolved in the sea by adhesion to air bubbles in the water, and that continued bubble formation resulted in the build-up of larger particles. In view of this, it is now proposed that organic conglomerates are continually being created in the ocean by the process of adhesion to air bubbles. An appreciable portion of this material remains available as stable food for the zooplankton, which are attracted to these masses and are thus concentrated in certain sea areas. This important theory explains how certain zooplankton are able to obtain sufficient food to maintain their populations, and—if born out by further work—has important implications in terms of the distribution and abundance of the commercially important predators involved in food cycles within the sea.

(2) A relationship between the Florida red tide and shellfish was discovered when materials, not previously known to be toxic to man, were identified in shellfish by the Public Health Service. A parasite responsible for meningitis in man was discovered in shellfish. Studies of the occurrence of E-type botulism found the causative organism to be much more widespread than had been suspected previously.

(3) Studies of the behavior of tuna and their responses to such factors as sound, temperature, and light, have given Bureau of Commercial Fisheries oceanographers new insight into the behavior patterns of this commercially important fish. This work promises to contribute to the solution of practical problems presently confronting the fisherman in developing new harvesting techniques. The Bureau has also developed serological techniques to define subpopulations of tuna, salmon, and groundfishes. This research is important to the international management of fishery resources.

(4) Newly formed land masses resulting from volcanic activity provide the marine biologist with a unique opportunity to conduct investigations of the biological invasion of denuded areas. Such a project is currently being sponsored by the

Office of Naval Research on the recently emerged island of Surtsey, off Iceland. Here the ecologist has the advantage of sterile conditions, new land of extensive area, and freedom from immediate influence by neighboring regions.

b. We are better able to describe the distribution of physical and chemical properties of the ocean, and to understand more fully the dynamic processes which affect this distribution.

(1) Recent investigations sponsored by NSF and ONR have been directed toward deep water waves and wave trains as they move up onto the continental shelf, undergoing deformation as they arrive in shallower water.

Quantitative descriptions of the directional spectra of ocean swells, attenuation, dispersion, and areas of origin, in the North Pacific are now available. Combined support has permitted the recent development of numerical methods for predicting the directional spectra of waves in the entire North Atlantic. These studies are excellent examples of combining theoretical and empirical information for the purpose of forecasting, which of course can be useful in the routing of merchant vessels.

(2) Marine scientists participating in the International Indian Ocean Expedition found the Arabian Sea to be, occasionally, oxygen poor with an attendant excess of hydrogen sulfide. This appears to be the cause for the discoveries of millions of tons of dead (asphyxiated) fish in certain areas of the Indian Ocean. It has now been fairly well established that these wholesale deaths are due to several factors, *i.e.*, subsurface water extremely rich in inorganic nutrients but very poor in dissolved oxygen, the rapid growth and production of plankton which use these nutrients and sunlight to produce organic matter, and the sudden upwelling of water over a broad area.

(3) The Bureau of Commercial Fisheries is now using its new understanding of large-scale variations in the physical properties of the ocean to make predictions of the availability of a number of commercially important fishes.

(4) Studies of the equatorial current systems sponsored by NSF, ONR and BCF seem to indicate that equatorial circulation is similar and symmetrical in the oceans. This is based on discoveries of an equatorial undercurrent some time ago in the Pacific, and recently, its counterpart in the Atlantic. It has also been demonstrated that a south equatorial counter-current exists in the Atlantic, and is associated with the monsoon winds of the Gulf of Guinea, which reverse their direction seasonally. A similar phenomenon has been observed in the Indian Ocean.

c. Although we have a long way to go, we have learned more about the interrelationships of the oceans and atmosphere.

Scientific investigations of the ocean and atmospheric systems have traditionally dealt with one system at a time. Through development of specialized instrumentation, meteorologists have linked continental observatories with more recently established observatories in the open ocean. Recently there has been a concerted attempt to approach air-sea interaction as a single interdisciplinary problem. Many studies are underway to determine the effect of the coupling of wind regimes with ocean water masses and current systems. Among these projects is an investigation of the partition of gases between aqueous and gaseous phases. Recently, NSF-supported scientists have discovered that nitrogen dissolved in ocean water does not exchange with the nitrogen of dissolved nitrates. This has important implications not only with respect to nitrogen in the sea and atmosphere, but also in the distribution and character of nutrients.

d. With new capabilities, we have been better able to describe the seafloor, and to understand its long-term and short-term evolution, its topography, geophysical nature, and subsurface structure. We have also learned more about the seafloor's relation to the surrounding land masses.

(1) Geophysical data—gravity, seismic, and magnetic—have been collected over wide regions of the Atlantic and Pacific Oceans. Fault zones have been located along the flank of the Puerto Rican Trench and major fracture zones have been found in the North Atlantic. One interesting finding is that the mantle under some parts of the mid-Atlantic ridge is of abnormally low density. It also appears that the thickest marine deposits are adjacent to the continental margin and that in many cases, they may have been deposited by massive submarine flows down the shelf. Bathymetric data accumulated by research and survey ships have allowed a more precise mapping of the ocean floor; numerous ridges, seamounts, ocean

deeps, and fracture zones have been, and are still being, found. When coupled with seismic and sedimentary data, this work is giving us a greater insight into the origin and evolution of the ocean basins. These projects are centered in the Navy, Coast and Geodetic Survey (ESSA) and in private institutions supported by NSF and ONR.

(2) One of the most significant recent accomplishments in oceanography was completion of an ocean drilling and coring program on the continental shelf, continental slope, and the Blake Plateau off the eastern coast of Florida. The drilling took place on six sites along a transect beginning about 22 miles off Jacksonville in 81 feet of water and extending 250 miles offshore where the ocean depth is 3500 feet. The deepest hole drilled extended 1050 feet below the seafloor. The project was supported by NSF and involved active participation by other Federal agencies. The operation was conducted under the supervision of the Joint Oceanographic Institutions Deep Earth Sampling (JOIDES) Committee, representing the laboratories concerned. Although only preliminary results are available, the success of the operation was demonstrated by the recovery of exceptionally deep ocean-bottom cores. Extrapolation of structure and lithology can now be made from the land outward across the continental shelf. Geological Survey gamma ray logs in the holes indicated commercially important phosphorite beds beneath the continental shelf. Collections of core samples at levels previously studied only with reflection profiles will be of great value in interpreting seismic data. Other benefits are: stratigraphic correlation of near shore and deep water fossil forms; new knowledge of the history of the continental margin; reappraisal of present theories about the continental shelf. Two fresh water aquifers were found at depths of 500-700 feet, 22 miles offshore; the artesian water had a head of more than 30 feet above sea level. This find greatly extends the known water reserves for this part of Florida.

(4) Studies of recent lavas that have been extruded from rifts on the ocean floor near Hawaii have provided new methods for determining relative movements of the sea floor and calculating the age of submarine volcanic rocks. Analyses of the depositional sequences of the lavas aid in the interpretation of depositional environments of ancient geologic deposits that now form parts of the land. Geochemical studies of the lavas are also aiding in the investigation of the mechanism by which the manganese deposits of the ocean floor are formed. Results of the studies, conducted by personnel of the Geological Survey's Hawaii Volcano Observatory with the cooperation of the Coast and Geodetic Survey, Japanese scientists and others, have broad applicability to the search for mineral resources both on the ocean floor and on land.

3. Survey Accomplishments

Both the traditional mission oriented surveys of the participating agencies and the oceanwide mapping surveys have shown solid accomplishments.

a. Navy has greatly increased its survey effort to meet urgent military requirements and has contracted with industry to conduct the recently inaugurated marine geophysical survey program. Moreover, Navy has expanded its program to include—where possible—programs of a nonmilitary nature to meet the needs of potential government, academic, and industrial users.

(1) Navy has conducted 13 separate hydrographic surveys in support of ASW and undersea warfare requirements.

(2) Navy has completed a number of specialized surveys. The AUTEC range in the Bahamas and another military oceanography range near the Virgin Islands were surveyed as was the coast of Colombia. In addition, two ship years were devoted to mine warfare studies.

b. The ESSA survey program has significantly advanced our knowledge of the ocean and increased our ability to use this knowledge.

(1) ESSA has accurately delineated the topography, gravity field, and magnetic field, of a large area of the Pacific Ocean. The area described extended from the Aleutian Trench to the Hawaiian Islands. A regional pattern of elongate magnetic lineations across the grain of the topography in the North Pacific was discovered during the Ocean Survey Program operations of the PIONEER.

(2) Scientists aboard the PIONEER discovered the Andaman Sea rift valley during the International Indian Ocean Expedition.

c. The Coast Guard (USCG) has made a major contribution to the safety of operations in the North Atlantic. Predictions of iceberg movement and deterioration are made on the basis of standard dynamic topographic charts constructed from over 25 years of USCG survey data in the Grand Banks area.

d. The Geological Survey has completed the first large scale contour map of the east coast continental shelf. The map, which was compiled from more than 1,800,000 soundings made by the Coast and Geodetic Survey, the Naval Oceanographic Office, various oceanographic institutions, and the Canadian Hydrographic Office, represents a major achievement in advancing our knowledge of the shelf. It will provide a base for plotting data on geological, hydrological, and biological conditions and resources. Scientists of numerous agencies and institutions have participated in the Geological Survey's exploration of the shelf aboard GOSNOLD, the survey vessel operated for Geological Survey by the Woods Hole Oceanographic Institution.

e. Bureau of Commercial Fisheries-conducted surveys have resulted in the discovery of large, unexploited fishery resources: hake and groundfishes off Washington and Oregon; shrimp off the southern Aleutians and the northeast coast of South America; and extensive beds of calico scallops off Florida. These discoveries promise to strengthen the U.S. fishing industry and improve the nation's competitive position in the world market—a major objective of the Bureau's program.

f. Public Health Service's Division of Water Pollution Control (now the Federal Water Pollution Control Administration) traced the flow patterns of water from the New York upper harbor through the narrows and into Raritan Bay. The studies showed the hazard created by the polluted waters of the upper harbor because they are diffused throughout the bay, and may remain there for as long as 30 days.

4. Ocean Engineering Accomplishments

Although newly identified in the Fiscal Year 1967 program, ocean engineering has long been conducted by several Federal agencies: Army's beach erosion and coastal engineering work, for example. Newest of the ocean engineering programs are the Deep Submergence Project of the Navy, and the joint Navy-AEC development of the nation's first nuclear powered oceanographic undersea research and engineering vehicle—*NR-1*.

Among the recent accomplishments resulting from the ocean engineering effort are:

a. SEALAB II, Navy's "Man-in-the-Sea" project (an element of the Deep Submergence Systems Project), conducted off La Jolla, California, in late 1965, proved, among other things, that one aquanaut living and working from an undersea habitat at 200 feet, without daily decompression, can perform as much work in six hours as 35 divers operating from the surface.

b. The Atomic Energy Commission, through its Systems for Nuclear Application Program (SNAP), provided several successful low power systems capable of being used both on and under the sea. A SNAP 7D generator was successfully used as a power source for the NOMAD oceanographic buoy anchored in the Gulf of Mexico. A very small generator has been developed for use in a sonic navigational buoy operating from the sea floor.

c. The Navy, in cooperation with industry, has developed a significant background of information on deep ocean engineering. Materials recovered from the Submerged Test Units (STU)—which had been submerged for more than two years at great depths—yielded valuable information on the reactions of many kinds of materials to the deep ocean environment.

d. Army Corps of Engineers analysis of data on the effectiveness of low crest breakwaters demonstrated that it is more economical to raise the elevation of breakwaters than to increase their width. Tests also established a satisfactory stable design for breakwaters with higher cores; such cores will reduce the effect of wave action through the permeable material of the breakwaters.

e. The Bureau of Commercial Fisheries has developed improved fishing gear to be used in catching hake. This new gear, successfully tested in the waters of the Pacific Northwest, promises to provide the fishermen with an increased capability of exploiting the newly discovered hake fishery in this area.

f. Among the accomplishments of NSF's Project MOHOLE was the development of a special down hole turbodrill, which will drill faster than

rotary drills and permits continuous coring. A retractable diamond bit has been developed which will permit bit changes without pulling the drill string. A sonar device for hole reentry is being developed. Several devices for down hole scientific measurements have been prepared and others will be developed. The logging winches and controls, under construction, and the longest logging cable ever developed (40,000 feet) are other engineering efforts of significance.

5. Recent Activities of the Interagency Committee on Oceanography

During calendar year 1965, the ICO through its panels and staff has engaged in a number of activities related to problems in the ocean environment, and has formulated the National Oceanographic Program. Prominent among these activities were:

a. In recognition of the growing economic potential of ocean development, the Committee identified Ocean Engineering as an area of special emphasis, and expanded the Fiscal Year 1967 program to include agency programs in this area. A seventh ICO panel, on Ocean Engineering, was established to coordinate Federal activities and monitor relevant industrial programs.

b. The ICO in its evaluation of the national oceanographic effort has enlisted the advice of industry through the National Industrial Security Association (NSIA). NSIA established the Ocean Sciences Technical Advisory Committee, as the focal point for industry's participation in the National Oceanographic Program.

c. Through the ICO/ICAS Joint Panel on Air-Sea Interaction, a national plan for combined oceanographic and meteorological research was proposed to the Federal Council. Elements of this program are included in the Fiscal Year 1967 program.

d. ICO member agencies participated successfully in the International Indian Ocean Expedition (IIOE), a concerted study, in cooperation with other nations, of the physical, chemical, and biological oceanography of this area and of the air/sea interchange, especially as it is influenced by the winter monsoons. The findings of the expedition are now emerging in professional journals.

e. International considerations are becoming a vital part of the national oceanographic posture. Recent steps taken toward extending ICO's participation in international programs were:

(1) A government-wide symposium (ICO-NASCO-State) on the role of marine sciences in foreign affairs.

(2) An interchange of U.S. and Soviet oceanographers.

(3) Preparation of position papers for Intergovernmental Oceanographic Commission meetings on oceanographic problems of international interest.

f. The ICO, recognizing the need for preliminary scientific exploration of the continental shelf, has:

(1) Identified specific portions of its program as they relate to the continental shelf.

(2) Held a joint ICO-industry meeting to discuss the roles of government and industry in exploration of the shelf.

(3) Established an *ad hoc* subpanel to investigate the scientific aspects of the continental shelf and propose the techniques for its development.*

g. ICO cooperated with other governmental advisory groups such as: the Federal Meteorological Coordinator, the National Academy of Sciences-Committee on Oceanography, the National Academy of Engineering-Committee on Ocean Engineering, and the Interdepartmental Committee on Atmospheric Sciences.

h. During the past calendar year the ICO participated in five congressional hearings and investigations, two OST panel reviews, five non-governmental reviews, and, of course, its Federal Council appearances. The ICO has been active in these proceedings and has also supplied large quantities of background information to Congressional committees.

i. The ICO published a comprehensive report on *Undersea Vehicles for Oceanography* (ICO Publication #18), which covers the technical and scientific requirements for these new oceanographic tools.

j. One of the auxiliary functions of ICO is to supply curricular information to prospective college students. ICO Publication #23, *University Curricula in Oceanography, Academic Year 1965-66,* was released early in 1966.

k. A report on the status of oceanographic manpower has been completed for the ICO by the

*The findings of this panel and the work of the Federal agencies on the continental shelf will be presented in a forthcoming ICO Publication.

International Oceanographic Foundation (NSF funded). Although originally restricted in scope, the report has been rewritten to incorporate a somewhat broader scope and was released early in 1966 as ICO Pamphlet #21, *Scientific and Technical Manpower in Oceanography.*

l. Another publication furnished annually by the ICO to the scientific community and the general public is the *Oceanographic Ship Operating Schedules,* ICO Publication #22. Programmatic scheduling of all oceanographic voyages is given for Fiscal Years 1966-67 in this recently released document.

m. In recognition of the need for compilation of articles and technical publications resulting from Federally funded projects on the marine sciences, the ICO has prepared a comprehensive bibliography which will be released as ICO Publication #20, *Bibliography of Marine Sciences Publications and Reports—1963-1964,* in 1966.

n. As part of its annual planning procedure the ICO has prepared a summary of current projects in oceanographic research. This document has been circulated throughout the ICO agencies.

o. A highly informative pamphlet has been prepared by the State Department for the ICO to assist the American ocean scientist in the preparation of his research cruises in foreign waters. ICO Pamphlet #25, *U.S. Oceanic Research in Foreign Waters,* provides valuable information on provisions of international law and on procedures to be followed so as to avoid delays in obtaining clearances from foreign governments. It is hoped that this publication will contribute to a more judicious use of cruise opportunities in promoting international cooperation.

p. The Organization for Economic Cooperation and Development proposed an international cooperative study of sea pollution. An ICO *ad hoc* panel on Sea Pollution has prepared a comprehensive review of current U.S. activities in this area and has submitted recommendations as to the extent of U.S. participation.

q. The ICO in addition to its industrial relationships acts as a focal point for information supplied to Federal agencies, academic institutions, State Governments, the industrial community, newspapers, and magazines. More than 30,000 copies of its publication *Opportunities in Oceanography* were distributed to the public.

r. Most important of the ICO activities has been, and will continue to be, the coordinated development and reporting of the annual National Oceanographic Program. The Fiscal Year 1966 National Oceanographic Program was forwarded to the Congress in March 1965.

II. PROPOSED FISCAL YEAR 1967 PROGRAM

A. Summary of Agency Missions

The National Oceanographic Program is a coordinated plan for oceanographic research and development consisting of the integrated programs of those agencies whose statutory missions encompass achievement of the national goals in oceanography. The Navy and the Advanced Research Projects Agency primarily have responsibility for defense. Interior's Bureau of Commercial Fisheries, Bureau of Sport Fisheries and Wildlife, Geological Survey, and the Bureau of Mines are responsible for ocean resources development. The Environmental Science Services Administration, Coast Guard, and Army Corps of Engineers are concerned with navigation and the protection of life and property at sea and along the coasts. The Maritime Administration's mission is to improve sea transport. The National Science Foundation, Office of Education, and Smithsonian Institution are primarily responsible for developing our basic research and manpower resources, and for maintaining the strength of U.S. science. The Atomic Energy Commission is responsible for verifying the safety of low-level radioactive waste disposal, and for determining the fate of nuclear materials in the ocean environment. The Public Health Service is concerned with protecting the health of our citizens. The Federal Water Pollution Control Administration is responsibe for assuring an adequate supply of water suitable in quality for all beneficial uses. The Department of State supports U.S. international commitments and provides leadership for cooperative scientific endeavors in the United Nations.

Obligations by these agencies for oceanography are shown in the following tables:

Table A
NATIONAL OCEANOGRAPHIC PROGRAM BUDGET, FY 1965-67
By Agency
(in thousands of dollars)

	Actual FY 1965	Estimated FY 1966	President's Budget FY 1967
Defense	$ 98,064	$ 80,484	$113,511
Commerce	20,099	13,118	16,408
Interior	20,171	19,466	19,427
National Science Foundation	44,000	43,200	43,000
Atomic Energy Commission	5,977	11,589	13,475
Health, Education & Welfare	5,247	6,320	9,686
Treasury	1,962	2,067	2,303
Smithsonian Institution	869	1,495	1,597
State	432	488	476
TOTAL	$196,821	$178,227	$219,883

Table B
NATIONAL OCEANOGRAPHIC PROGRAM BUDGET, FY 1965-67
By Functional Area
(in thousands of dollars)

	Actual FY 1965	Estimated FY 1966	President's Budget FY 1967
Research[1]	$ 70,539	$ 81,444	$ 84,274
Surveys	26,300	29,543	38,441
Ocean Engineering	61,953	40,651	65,951
Ship Construction	20,700	12,490	16,189
Instrumentation	10,329	9,436	8,437
Facilities	5,984	3,483	5,228
Data Center	1,016	1,180	1,363
TOTAL	$196,821	$178,227	$219,883

[1]Includes International Indian Ocean Expedition and Ocean Sediment Coring Program.

Table C
INDIVIDUAL AGENCY BUDGETS
(in thousands of dollars)

Agency Functions	Actual FY 1965	Estimated FY 1966	President's Budget FY 1967
DEFENSE—TOTAL	$98,064	$80,484	$113,511
Navy—Total	95,533	77,938	110,116
Research	30,422	31,210	32,149
Surveys	14,704	15,336	22,211
Ocean Engineering	34,306	14,251	35,711
Ship Construction	9,000	11,100	13,800
Instrumentation	6,629	5,453	5,623
Data Center	472	588	622
Army—Total	1,096	1,346	2,295
Research	507	637	1,057
Ocean Engineering	576	696	1,220
Data Center	13	13	18
Advanced Research Projects Agency—Total	1,435	1,200	1,100
Research	525	550	700
Instrumentation	910	650	400
COMMERCE—TOTAL	$20,099	$13,118	$16,408
Environmental Science Services Administration—Total	20,049	13,068	16,358
Research	1,070	1,186	2,290
Surveys	8,827	10,598	11,370
Ship Construction	9,000	—	1,689
Instrumentation	600	1,062	750
Facilities	360	—	—
Data Center	192	222	259
Maritime Administration—Total	50	50	50
Research	50	50	50

Table C (continued)
INDIVIDUAL AGENCY BUDGETS
(in thousands of dollars)

Agency Functions	Actual FY 1965	Estimated FY 1966	President's Budget FY 1967
INTERIOR—TOTAL	$20,171	$19,466	$19,427
Bureau of Commercial Fisheries—Total	18,383	17,366	17,629
Research	11,771	13,575	14,345
Surveys	1,445	1,654	1,787
Ocean Engineering	—	270	270
Ship Construction	1,700	690	—
Instrumentation	800	800	900
Facilities	2,500	210	160
Data Center	167	167	167
Bureau of Sport Fisheries & Wildlife—Total	901	1,006	701
Research	401	658	638
Surveys	—	38	38
Instrumentation	—	—	25
Facilities	500	310	—
Geological Survey—Total	753	860	862
Research	581	677	679
Surveys	15	15	15
Instrumentation	127	138	138
Facilities	20	20	20
Data Center	10	10	10
Bureau of Mines—Total	134	234	235
Ocean Engineering	134	209	210
Facilities	—	25	25
NATIONAL SCIENCE FOUNDATION—TOTAL	$44,000	$43,200	$43,000
Research	15,700	22,000	20,000
IIOE	(3,727)[1]	(1,400)[1]	—
Ocean Sediment Coring Program	—	(5,400)[1]	(1,300)[1]
Ocean Engineering (Project MOHOLE)	24,700	17,900	19,700
Ship Construction	1,000	700	200
Facilities	2,500	2,500	2,900
Data Center	100	100	200

[1]Included in Research.

Table C (continued)
INDIVIDUAL AGENCY BUDGETS
(in thousands of dollars)

Agency Functions	Actual FY 1965	Estimated FY 1966	President's Budget FY 1967
ATOMIC ENERGY COMMISSION—TOTAL	$5,977	$11,589	$13,475
Research	3,703	4,227	4,598
Ocean Engineering	2,237	7,325	8,840
Data Center	37	37	37
HEALTH, EDUCATION & WELFARE—TOTAL	$5,247	$ 6,320	$ 9,686
Public Health Service—Total	3,115[1]	3,534[1]	5,613
Bureau of State Services—Total	1,175	1,434	3,363
Research	1,100	1,060	1,083
Surveys	30	130	167
Instrumentation	45	45	—
Facilities	—	194	2,108
Data Center	—	5	5
National Institutes of Health—Total	1,940	2,100	2,250
Research	1,940	2,100	2,250
Federal Water Pollution Control Administration—Total	2,055[1]	2,621[1]	3,809
Research	1,405	1,499	2,033
Surveys	650	699	1,470
Instrumentation	—	417	300
Data Center	—	6	6
Office of Education—Total	77	165	264
Research	77	165	264

[1]Public Health Service and Federal Water Pollution Control Administration programs for FY 1965 and FY 1966 are presented separately for program comparison purposes. However, water pollution control activities were removed from the Public Health Service December 31, 1965, and placed in the newly established Administration. The Administration's first separate budget was prepared for FY 1967.

Table C (continued)
INDIVIDUAL AGENCY BUDGETS
(in thousands of dollars)

Agency Functions	Actual FY 1965	Estimated FY 1966	President's Budget FY 1967
TREASURY—TOTAL	$ 1,962	$ 2,067	$ 2,303
Coast Guard—Total	1,962	2,067	2,303
Research	60	61	65
Surveys	629	1,073	1,383
Ship Construction	—	—	500
Instrumentation	1,218	871	301
Facilities	30	30	15
Data Center	25	32	39
SMITHSONIAN—TOTAL	$ 869	$ 1,495	$ 1,597
Research	795	1,301	1,597
Facilities	74	194	—
STATE—TOTAL	$ 432	$ 488	$ 476
Research	432	488	476
TOTAL	$196,821	$178,227	$219,883

PART TWO

Oceanographic Effort

I. Scientific Exploration - the Research Effort
II. Geographical Exploration - the Survey Effort
III. Maritime Development - the Ocean Engineering Effort

I. SCIENTIFIC EXPLORATION

The Research Effort

Oceanographic research remains the largest single element in the National Program. While carrying over much of the effort reported last year, new programs will be inaugurated; these are reported in the agency program descriptions at the end of this section. Of particular interest are the following *program highlights.*

1. *New Agencies*—The oceanographic research programs of the Advanced Research Projects Agency in the Department of Defense, and of the National Institutes of Health, have been incorporated in the program, thus broadening the scope of the research effort. Budgets for Fiscal Years 1965 and 1966 have been changed retroactively to reflect the addition of these programs.

2. *Agency Reorganizations*—The past year has witnessed three reorganizations which affect the research program. In the Department of Commerce, the Environmental Science Services Administration was created in mid-1965. Much of the research formerly supported by the Coast and Geodetic Survey and Weather Bureau, was transferred to the newly established Institutes for Environmental Research. In the Department of Health, Education and Welfare, the Division of Water Supply and Pollution Control, was transferred from the Public Health Service to the newly created Federal Water Pollution Control Administration, established by the Water Quality Act of 1965. The Division of Water Supply and Pollution Control was abolished. The National Science Foundation has reorganized its research divisions and established a division of Environmental Sciences. The Earth Sciences Section in this new division includes the Office of Antarctic Programs and is responsible for the Foundation's physical oceanographic effort. Biological oceanography remains within the Division of Biological and Medical Sciences apart from physical oceanography.

3. *Air-Sea Interaction*—The program for FY 1967 reflects the initial phase of a Federally-coordinated air-sea interaction program, based upon a recent report prepared by the Department of Commerce and reviewed by the Joint ICO/ICAS Air-Sea Interaction Panel.

4. *Biological Oceanography*—One of the reasons for the organization of the International Indian Ocean Expedition (IIOC) and the International Cooperative Investigation of the Tropical Atlantic (ICITA) was the necessity of investigating the biological resources of these areas. In order to further increase our knowledge of the biology of the oceans, the ICO continues to coordinate Federal agency efforts in biological oceanography and is identifying problems and opportunities in this field.

5. *Ocean Forecasting*—The U.S. has recently made significant advances in the technology of forecasting oceanographic conditions; the Navy's Antisubmarine Warfare Environmental Prediction System (ASWEPS), for example, has enabled fleet commanders to predict conditions important to undersea warfare in a large and continuously monitored section of the North Atlantic. Other ocean forecasting efforts are also under way to achieve nondefense objectives, such as the safe, efficient routing of merchant ships. The ICO believes it is vital to assess the state-of-the-art in ocean forecasting so that present efforts can be given greater coherence and direction. Toward this end, a special subpanel on ocean forecasting has been convened. The results of its study will be reflected in the FY 1968 research programs of the agencies concerned.

6. *Undersea Research Vehicles (URV)*—ICO agencies plan to take full advantage of the new capabilities offered by undersea research submersibles. Some of the research programs planned for FY 1967 will benefit from the use of these promising tools. Recently constructed URVs will be chartered to obtain operating experience, and to evaluate their usefulness in oceanographic research. The present state-of-the-art is summarized in the recently published ICO Pamphlet No. 18, *Undersea Vehicles for Oceanography.*

7. *Oceanographic Tools*—Some ICO agencies include the cost of procuring instrumentation in their research budgets. For example, both the National Science Foundation and the Office of Naval Research estimate that about 15 percent of

their respective research budgets go for instrumentation procurement. In FY 1967, a substantial portion of these funds will be used for improving existing equipment.

8. *Ship Operating Costs*—The cost of operating research vessels remains a major expense in the program. Approximately 25 percent of the research budget will support ship operations. The National Science Foundation, Office of Naval Research, and the Bureau of Commercial Fisheries are the major agencies which fund ship operations from their research budgets.

9. *International Cooperation*—Although U.S. scientists continue to cooperate with oceanographers of other nations, obligations for support of formal international oceanographic programs are down sharply from previous years. This reflects the termination of the International Indian Ocean Expedition (IIOE). During FY 1967, data collected over the past five years will be processed. Elucidation of theory from data analysis will continue. Charts, atlases, and other materials will be produced.

Through their participation in the International Biological Program (IBP) of the International Cooperative Year (ICY), marine biologists from the United States will continue to work with those from other nations in FY 1967. The objective of the IBP in biological oceanography is to advance our knowledge and understanding of the processes that control the distribution and development of marine populations and communities.

During FY 1967, ICO, working through its Panel on International Programs (PIPICO), will continue to participate in the activities of the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The Commission sponsors international programs for study of the ocean; *e.g.,* IIOE was the first formal program sponsored by IOC. PIPICO's recent recommendation for full U.S. membership in the International Council for Exploration of the Seas (ICES), when ratified, will make ICO the logical center of U.S. activity in this oldest international cooperative body engaged in ocean exploration. In conjunction with the work of PIPICO, the Committee also plans to extend the scope of its activities to include investigations into the law of the sea.

10. *Continental Shelf*—On May 25, 1964, the President of the United States proclaimed enactment of a multilateral convention for the exploitation of the continental shelf. The Convention on the Continental Shelf came into force June 10, 1964, after ratification by the United States and forty-five other countries. Under the terms of the Convention, this nation's sovereign rights to explore the shelf and exploit its resources were extended over at least 850,000 square miles of ocean bottom—an area equivalent to approximately 25 percent of the continental United States. The Convention defines the United States continental shelf as the seabed and subsoil of the submarine areas adjacent to the continent and island coastlines of the United States but outside the area of the territorial sea, to a depth of 200 meters or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of natural resources. Thus, not only are our Federal rights on the seabed clearly defined to the 200-meter limit, but implicit in the treaty is recognition that, with advances in our undersea technology, these rights could be extended into deep ocean areas beyond the shelves. This treaty has focused the ICO's attention on the shelf, and its exploitation potential.

The significance of the continental shelf is its closeness. Modern technology, with very little extension of the state-of-the-art, can overcome the difficulties which have long prevented its exploration and development. Indeed, advanced deep ocean recovery techniques are now being employed by the U.S. petroleum industry that will open new vistas in oil exploration beyond 200-meter depths.

Since the shelf is an extension of the continental land masses, its geological features are similar in nature to those of its adjacent coastlines. Developing those areas where geological processes have fortuitously concentrated mineral deposits may contribute to our gross national product. But mineral deposits are only a part of the wealth of the continental shelf. Much of our national fisheries activity is concentrated on the shelf. Shellfish are abundant in the estuaries and nearshore areas. Bottom dwelling species, which comprise a large percentage of our total fish catch, are found within the geographic limits delineated by the 200-meter depth contour. By international convention we have sovereign rights for the exploitation of bottom

dwelling organisms of the continental shelf, although our fishermen cannot claim the same exclusive rights respecting fish in all the waters *above* the shelf.

Installations for the simultaneous desalination of water, generation of electricity, and extraction of dissolved chemical substances may very well stimulate further industrial expansion along our coasts. Even now studies are underway to determine the net effect of such installations on the natural ecological balance of the marine environment.

Another area of concern is the effect of urban and industrial expansion on nearshore recreational areas. The waters of the continental shelf must be used for waste disposal. The long term purifying effect and vast space of the ocean makes it an excellent processing facility for industrial and municipal wastes. This use too, if improperly managed, can upset the natural balance of nearshore areas.

The ocean boundaries of our country also represent an important resource for recreation. Even now State governments are pooling their capabilities for the development of large portions of their common coastlines. With the increased number of beaches, marinas, and other ocean related recreation sites, a heavy responsibility will be placed on those agencies concerned with the health and welfare of individual Americans enjoying the ocean. Thus, as development of mineral, animal, and recreational resources proceeds, it is apparent that scientific management practices must be initiated to conserve the shelf environments.

As industry and the public are encouraged to develop and use the resources of the continental shelf and its overlying waters, it is incumbent upon the Federal government to assess—now—the scientific requirements and specific opportunities inherent in exploration of this territory, newly acquired by the United States as a result of the convention.

In recognition of this potential, the ICO will identify the total Federal effort on the continental shelves in a document to be released later this year, and incorporate this effort in the FY 1968 National Oceanographic Program. Agency programs contributing to our knowledge of the shelf and its contents are identified in the Research, Surveys and Ocean Engineering sections of this document and represent about 40 percent of the national oceanographic effort.

* * *

DEPARTMENT OF DEFENSE

Department of the Navy

FY 1965—$30,422,000
FY 1966—$31,210,000
FY 1967—$32,149,000

Background

Among its many assigned missions, the Department of Defense is responsible for maintaining sufficient mastery of the sea to prevent sea-launched attacks upon the United States and her allies, and for projecting this power to any part of the world when necessary for national security. Within the Department of Defense the Navy has the responsibility for developing the weapons, equipment, vehicles, and tactics necessary for mastery of the ocean. This responsibility demands an intimate knowledge of the Navy's operational environment above and on the ocean's surface; throughout its vast, ever-changing water mass; and on and beneath the seabed. To obtain this essential knowledge, the Navy has undertaken a broad oceanographic research effort, with programs centered in three major elements of the naval establishment: (1) Office of Naval Research; (2) Naval Material Support Establishment (which includes the Naval laboratories); and (3) Naval Oceanographic Office. In FY 1967, these programs are expected to contribute further to the broad national goal—Improving National Defense—by advancing our knowledge of the marine environment and thus contributing to naval systems development, ship and equipment design, and operational fleet readiness.

Office of Naval Research

FY 1965—$21,410,000
FY 1966—$21,927,000
FY 1967—$22,222,000

Background

The main objective of the Office of Naval Research ocean sciences program is to build up a

national competence in oceanographic research so that the basic knowledge, trained personnel, and technical proficiency will be available to meet the present and future needs of the Navy. Toward this end, the Office of Naval Research has encouraged the establishment and growth of laboratories and educational facilities throughout the United States, and has supported well-qualified investigators with grants for research proposals of merit. The Office has enhanced research capabilities at institutions by providing funds for the construction or conversion of ships. (For the 24 major oceanographic ships operated by private laboratories in FY 1966, and jointly funded by Federal agencies, more than half the support came from ONR). Many specialized facilities have been developed by, or made available to research personnel: *e.g.,* FLIP, a highly stable, mobile research platform; the deep research vehicle, ALVIN; four-engined research aircraft; telemetering buoys; stationary towers; Arctic drift stations; and many special facilities for biological research.

While building up and maintaining a broad, institutional capability, ONR has stressed continuity of research support in an effort to provide stability in a field of science where capital and operating costs are higher than in most other fields of science. In recent years, however, the growth of support for oceanography, by the National Science Foundation and other Federal agencies, has allowed ONR to shift a larger amount of its support from fostering and maintaining oceanographic capabilities at private laboratories, to using these new capabilities to systematically increase our knowledge of ocean phenomena, especially in those problem areas of immediate concern to the Navy. Thus the Navy is shifting emphasis from broad institutional support (with laboratory programs developed largely along lines determined by the directors and their staff) to a stronger research program directed toward the solution of well-defined scientific problems of immediate Navy concern.

With past exploratory work as background, and recent advances in technology available for research at sea, we are now in a position to design significant *experiments* in the ocean. Among the most obvious opportunities (and most rewarding from both the scientific and the Navy points of view) are programs that will take advantage of our new technology to understand the dynamics and variability of the ocean through the use of time-series experiments. Since some time-series studies must be made in large areas over long periods (*e.g.,* investigation of major circulation patterns in the Eastern Pacific), they will be expensive; some will be beyond the capability of a single institution.

The pursuit of knowledge by numerous independent groups has been historically productive in science in general and notably in oceanography. A point is reached, however, when a concerted attack on definable problems is required. A number of scientists under ONR contract are documenting critical experiments in physical oceanography which are feasible and which promise to enlarge our understanding of the ocean. In FY 1967, ONR intends to marshall its resources behind some of the most attractive of these experiments.

Proposed FY 1967 Program

Through contracts with over 125 universities, nonprofit institutions, and a lesser number of industrial laboratories, and by means of an active in-house program at the Naval Research Laboatory, the Office of Naval Research will continue long-range support of oceanographic studies in areas of known relevance to the Navy. Parts of the program are directed toward filling gaps in knowledge that bear on recognized operational problems; other portions explore the applicability of existing knowledge to the Navy's use of the marine environment.

Problems in Basic Oceanography—Major program support will continue to go to the following institutions:

Woods Hole Oceanographic Institution
Scripps Institution of Oceanography,
  University of California, San Diego
Lamont Geological Observatory,
  Columbia University
University of Washington
Chesapeake Bay Institute,
  Johns Hopkins University
Texas A&M University

Narragansett Marine Laboratory,
University of Rhode Island
Institute of Marine Sciences,
University of Miami
Oregon State University
Massachusetts Institute of Technology
Graduate Research Center of the Southwest

Most of these institutions are involved in teaching as well as contract research; about 150 graduate students will be supported in FY 1967. Approximately 30 percent of ONR's FY 1967 research budget will be used to operate ships which either belong to the contractor or have been provided by the Navy to support investigations.

ONR will continue to stress basic scientific investigations of interest to the Navy. Oceanographers will attack problems in the following areas:

Descriptive Oceanography—The distribution of physical and chemical parameters and ordered motion in the sea.

Dynamics of Oceans—Growth and decay of waves at or below the surface of the ocean; current systems and turbulence (with a view toward formulating rules governing the response of the oceans to impressed forces).

Interactions of Atmosphere and Ocean—Radiation and mass balance across the interface.

Ocean Data System—Research using this recently developed system of long-range telemetering buoys will be inaugurated in FY 1967 to support investigations in the above areas.

Nuclear Techniques—Applications by the Naval Research Laboratory to oceanography; activation analysis of the distribution of uranium and radium in the ocean and its sediments. One goal will be perfection of gas chromatography techniques for use aboard ships in determining trace quantities of organic material in the ocean.

Chemistry of Oceans—Thermodynamics of sea water; distribution and reactions of trace elements; occurrence and implications of dissolved organic matter.

Geology and Geological Processes—Sedimentation and the geochemistry of the oceans.

Geophysical Structure of Ocean Basins—Reflection and refraction seismology; gravity and magnetic observations; heat flow measurements.

Biological Conditions—Effects bearing upon physical, chemical, and geological phenomena will be investigated.

Also, in FY 1967, research will be supported to learn as much as possible about the role of biological organisms in the sea with a view toward discovering conditions which may affect naval plans and operations. The ability to predict and/or control natural biological activities is one of the major military goals of the program. The scientific approach to these goals is to learn through observation, experimentation, and analysis the life histories of organisms, their physiological and biochemical metabolic processes and products, and their behavior in response to environmental influences and conditions. Information gained from this research will be applied to such problems as:

Interrelationships of marine organisms and the interaction of the biological components of natural waters with physical, chemical, and geological conditions.

Activities of boring and fouling organisms, their life histories, and their geographic, seasonal, and depth distribution.

Behavior patterns associated with sound production and mechanisms of sound production by animals, especially as they interfere with acoustic signalling during naval operations.

Effect of concentration of biological material on the underwater transmission of sound and light.

Occurrence of bioluminescence, its biological significance and the mechanisms of production and control.

The biology of dangerous aquatic animals such as sharks. Poisonous and toxic organisms are also studied to learn more about their behavioral responses and the pharmacological aspects of toxins.

Problems in Undersea Warfare—This exploratory development program is broad in concept, embracing the fields of oceanography, physics, submarine geophysics and geology. Key elements are bathymetry, seismology, gravity,

magnetics, heat flow, bottom and sub-bottom studies, signal processing, and theoretical as well as experimental studies of the dynamics of sound propagation.

Experiments will be conducted from oceanographic research ships, the research platform FLIP, and the undersea research vehicle ALVIN. Most of the work will be performed under contract at the Woods Hole Oceanographic Institution, the Marine Physical Laboratory of the Scripps Institution of Oceanography, and the Hudson Laboratory of Columbia University, and will be integrated with other military oceanography programs and with the national effort.

Continental Shelf Problems—Much of the ONR program bears on problems of the continental shelf although few of the research tasks are so circumscribed as to fall entirely within this geographic region. Conversely, most of the tasks can be expected to yield some information pertinent to the shelf.

Some of the areas of concern in research programs are associated with the shelf and slope.

Sediments, erosion, and sedimentation.

Geomorphology of the shelf and slope, especially of submarine canyons.

Structural geology using geophysical techniques.

Ecology of marine communities with some emphasis on fouling organisms.

Biology of marshes, estuaries, and other inshore areas.

Interactions between the sea and the atmosphere.

Processes of wave modification on entering shallow water.

Internal wave phenomena.

Turbulence and the dispersion of materials in estuaries and in the open water of the shelf.

Currents and their controlling dynamics.

Surf generation and its effectiveness in moving beach material.

Processes that shape the coast.

It is estimated that research activities on the continental shelf are being funded at a level of approximately $2.3 million in FY 1966. No significant change is anticipated for FY 1967.

Naval Material Support Establishment

FY 1965—$4,899,000
FY 1966—$4,747,000
FY 1967—$4,887,000

Background

The oceanographic research programs of the Bureaus of Ships and Weapons now come under the cognizance of the Chief of Naval Material as a part of the Naval Material System Establishment (NMSE). The Bureau of Yards and Docks and the Deep Submergence Systems Project, also a part of NMSE, report their respective oceanographic R&D efforts as "Ocean Engineering" (Part Two, Section III).

Laboratories and field activities maintained by BuShips and BuWeps represent important capabilities in terms of the total Navy oceanographic program and the National Oceanographic Program. Although much of the research conducted at these laboratories is highly specialized and very strongly oriented toward solving specific military problems of urgent national concern, very significant scientific contributions have been made by BuShips and BuWeps personnel which have enhanced our national understanding of the ocean. Both material bureaus were among the first laboratories to recognize the potential of undersea vehicles, and to translate their experience and requirements into operational systems (TRIESTE II, DEEP JEEP, TV-1A). While neither bureau has a continential shelf program *per se*, both are vitally interested in the shelf environment as it affects the performance of naval systems and equipment, (mine warfare, salvage, submarine detection, *etc.*), and both have identified certain portions of their total effort which will further the proposed ICO Continental Shelf Program.

Bureau of Ships

FY 1965—$3,993,000
FY 1966—$3,841,000
FY 1967—$3,977,000

Background

Bureau of Ships conducts 80 percent of its research effort in oceanography at two Bureau

laboratories—U.S. Navy Underwater Sound Laboatory (USNUSL) and the U.S. Navy Electronics Laboratory (NEL). Its program is directed primarily toward determining environmental factors which are important in underwater acoustics, electromagnetic radiation, and subsurface hydrodynamics. BuShips has been active for many years in the special problems of the Arctic, and has an active interest in air-sea-ice interaction.

Proposed FY 1967 Program

Bureau of Ships will continue to support a broad program in oceanography. Both USNUSL and NEL will conduct investigations at sea using AGOR's and submarines. Computer and other analyses will be conducted at shore facilities of sound transmission loss, and bottom reflectivity characteristics, especially as they affect modern long range sonar. Close cooperation will be maintained between NEL, USNUSL, and the Lamont Geological Observatory (Columbia University) in determining acoustical characteristics of the ocean bottom. The effects of internal waves, bubbles, and gas content on the propagation characteristics of surface waters will be investigated from an oceanographic tower at NEL. Also at NEL, a new approach to the use of oceanographic data in acoustic studies, "Oceanometrics" will be further developed. This project combines features of acoustical theory, electronic know-how, statistical theory, and oceanographic information in determining the acoustic variability of ocean regions. The NEL Arctic Research Pool will continue to be used by investigators to simulate Arctic conditions in research into the formation of sea ice. Field stations on Cape Prince of Wales, Alaska, and in the Canadian archipelago will provide NEL with related environmental data.

In addition to acoustically-oriented research, USNUSL and NEL will study the electromagnetic properties of the surface layers of the sea using undersea vehicles. The Bureau will continue to support a project at the Naval Research Laboratory on surface effects resulting from the passage of a submarine.

Investigations of high-frequency surface noise spectra will be made at the University of Miami. Additional research will go forward at the five other BuShips laboratories:

Mine Defense Laboratory—Measurement of pressure wave spectra in shallow water.

David Taylor Model Basin—Determination of wave spectra for sea-keeping model studies in tanks.

Radiological Defense Laboratory—Investigations of the structure of radiological background in the sea.

Applied Science Laborarory—Study of microorganisms affecting corrosion.

Marine Engineering Laboratory—Investigations of sea water under high pressure.

Bureau of Naval Weapons

FY 1965—$906,000
FY 1966—$906,000
FY 1967—$910,000

Background

The Bureau's continuing program in oceanography is directed toward achieving a better understanding of the effects of the marine environment on the performance of naval weapon systems. Since many of these systems are equipped with acoustic devices, the relationships and effects of ocean properties and of the sea bottom on the behavior of underwater sound must be studied. Other weapon systems require a broader understanding of the magnetic and gravitational fields at the bottom of the ocean, and the exchange of energy across the air-sea interface.

Proposed FY 1967 Program

In FY 1967 BuWeps laboratories will use new oceanographic research ships for experiments important to system design and development and to predict systems performance. Laboratories will continue to study the behavior of underwater sound in relation to the physical and chemical properties of the ocean. Of particular concern will be the nature and degree of variability of such behavior, both horizontally and with depth, and the extent to which it affects the performance of naval systems.

Naval Oceanographic Office

FY 1965—$2,113,000
FY 1966—$2,036,000
FY 1967—$1,978,000

Background

The research program at the Naval Oceanographic Office (NAVOCEANO), the only Navy laboratory devoted entirely to oceanographic problems, is oriented toward the basic mission of the Office: to support the combat effectiveness of the Navy by securing, analyzing, and disseminating oceanographic and hydrographic information essential to the national defense, and to carry out related programs contributing to maritime safety and to the national welfare as it pertains to the sea.

Oceanographic research at NAVOCEANO encompasses many scientific disciplines including physical, biological, chemical, and geological oceanography as well as observation and study of air-sea interaction. Marine gravity and geomagnetism as they influence navigation and other systems are closely studied in Project Magnet and Sea Scan. During FY 1966, NASA requested that the Navy initiate a cooperative program to define possible oceanographic experiments of a peaceful and scientific nature that might be conducted from orbiting spacecraft. This program, entitled the "Spacecraft Oceanography Project" was assigned to the U.S. Naval Oceanographic Office.

Proposed FY 1967 Program

Long Range Sonar—This project will develop techniques for utilizing global oceanographic information to predict underwater sound propagation and will support the design and operation of Navy long range sonar systems. Deep sea thermistor array systems will be used in conjunction with studies of turbulence, microthermal structure, microbubbles, acoustic impedance variations and other short period fluctuations which exist in the water column. Field emphasis will be directed toward obtaining time-series profile data. A special volume reverberation study will be conducted wherein all environmental parameters will be measured simultaneously for interpretation of bio-acoustic effects. Continued efforts will be directed towards study of the complex interaction of acoustic energy at the bottom interface with emphasis placed on the development of improved models. A shipboard system which obtains a sound speed profile and processes the data for computer input will be tested. Work on a recording sea surface scattering strength instrument will be initiated.

Polar Ice Prediction—This program is designed to improve the physical understanding and predictability of the distribution, formation, accretion, drift, deformation, and disintegration of floating sea and land ice forms. Special objectives are to determine the causal processes governing the frequency, origin, and stability of open water features through which submarines may surface. Other studies include the frequency, extent, and character of pressure ridges which interfere with the safety and speed of operating submarines and which may affect arctic weaponry. Data acquired in this program will permit improved estimates of the magnitude and variability of the mass budget of polar ice and consequently, the global heat balance.

A primary subtask is to test and evaluate all-weather remote sensing systems and to develop imagery interpretation techniques. Aircraft, ships, and drifting ice floe stations will be used as platforms for data collection.

Wave Forecasting—This program is designed to develop new or improved wave observation, analysis, and prediction methods. This will support Navy and commercial ship routing, coastal construction, and amphibious operations. Four sub-tasks comprise the overall effort. They are: (1) Development and testing of an automated numerical wave prediction technique on an oceanwide basis; (2) Study of the two-dimensional wave spectrum by stereophotography; (3) Development of a theoretical wave model; and (4) Determination of the mechanics of wave generation by cross-spectrum analysis of wind and wave data close to the sea surface.

Nearshore Environmental Prediction—This program will infer oceanographic conditions in harbors and other nearshore areas where environmental data are sparse or unavailable. Prediction techniques have been prepared for surface waves, water temperature, and salinity (density, conductivity). Preliminary investigations have been completed for bottom materials and tidal

currents. Investigations now in progress include marine fouling, bioluminescence, underwater visibility, and bottom pressure fluctuations.

Radioisotopic Oceanography—This project will be carried out in cooperation with the Atomic Energy Commission. The research will utilize both natural and radioisotopes which are artificially introduced into the sea as tracers of ocean water circulation, mixing, and other dynamic oceanographic processes. Direct shipboard measurement will be taken using submersible detectors, and various types of marine environmental samples will be collected for laboratory analysis ashore.

During the summer of 1965, samples of air, sea water, surface plankton, and bottom sediment were collected and returned for laboratory analysis of their radioisotope constituents. These samples will be utilized to study basic oceanographic features as revealed by the long-term transport and deposition of artificial radionuclides.

Joint research with the Naval Ordnance Laboratory on the *in situ* gamma radiation spectra is being conducted on a continuing basis.

Spacecraft Oceanography—This project will investigate and evaluate the possible application of remote sensors and spacecraft techniques to obtain oceanographic data, and to develop interpretation and display procedures to permit a useful application of these data.

Experiments are planned to test and assess the employment of remote sensors, such as infrared, microwave, radar, and photography, for the purposes of providing required information on oceanographic features and phenomena such as waves, thermal conditions, ice, icebergs, shoals, *etc.* An experiment will be conducted at Goose Bay, Labrador, employing remote sensors aboard aircraft to obtain ice data which will be correlated with measurements obtained by ground parties. Another experiment employing airborne remote sensors will be conducted in the vicinity of ARGUS ISLAND, Bermuda, to evaluate scatterometer data in relation to wave height measurements obtained by other means. Additional experiments will be sponsored during FY 1967 involving spacecraft, aircraft, and surface techniques to obtain data for evaluating instruments and techniques as they apply to providing various types of oceanographic data.

Navy Acre—This project will collect detailed three-dimensional oceanographic data over an extended period of time from a one degree square in the North Atlantic Ocean.

To collect these data, eight oceanographic buoys of the Antisubmarine Warfare Environmental Prediction System (ASWEPS) program will be utilized. Each buoy will telemeter information from a series of 25 temperature sensors located between the surface and a depth of 1,000 feet over a period of six months. They will also report wind speed and direction, air temperature, and barometric pressure. By locating the buoys in a grid network in a limited area, it is possible to establish the nucleus of a three-dimensional measurement system for ocean dynamics studies while at the same time accomplishing necessary test and evaluation of the instruments themselves. In addition, at least three strings of current meters will be placed within the area to obtain measurements over a period of at least one month. Data will also be collected in the area from research vessels.

Other—Certain other efforts are being conducted on a modest basis. These include: a program to improve capability for rapid retrieval and display of textual and graphic oceanographic and hydrographic information; a study to develop techniques and equipment to evaluate, compile, and reproduce data required for navigation charts and publications; and a study to develop improved techniques for determining the earth's gravity field at sea.

Navy Laboratory Ship Operations

FY 1965—$2,000,000
FY 1966—$2,500,000
FY 1967—$3,062,000

The Naval Oceanographic Office operates AGOR research vessels to meet the requirements of all Navy laboratories conducting the programs described above. A total of $3,062,000 has been included in the Navy ICO research budget to fund the operations of these ships in FY 1967.

* * *

Department of the Army

U.S. Army Corps of Engineers

FY 1965—$ 507,000
FY 1966—$ 637,000
FY 1967—$1,057,000

Background

The Army Corps of Engineers has long been responsible for maintaining and improving ship channels into coastal harbors. More recently it has been given responsibility for protecting shores and beaches from the processes of erosion and for preventing the flooding of coastal areas by hurricanes and tsunamis. The increasing use of shore areas and nearshore waters for recreation has given a new impetus to the building of small craft harbors with suitable access channels and to the restoration and widening of eroded beaches. To accomplish these tasks the oceanographic research program of the Corps of Engineers is wholly concerned with the problems of land-sea interaction. It should, thus, be classified as a continental shelf program. The work is conducted principally at the Coastal Engineering Research Center, Washington, D.C., and at universities and private institutions.

Proposed FY 1967 Program

Wave Action in Coastal Waters

Most of the damage to beaches and shore protection structures is caused by the action of ocean surface waves upon them. Prediction methods are presently available for most forms of wave action. These methods are, however, often uncertain and inaccurate. The Corps will, therefore, continue its research into the characteristics of ocean surface waves, their generation, propagation, transformation, breaking and action on shores and coastal structures. Like all Corps of Engineers research projects, these investigations will be conducted in the laboratory and in the field. Results will make possible the improvement of design criteria for beach restoration and the building of coastal structures.

Shore Processes

This project has the purpose of gaining an improved understanding of the processes involved in the interaction of the natural shore with the forces of wave, wind, tide, current, and surge imposed upon it, and the reaction of the shore and shoreline to these forces and processes. The mechanics of movement of littoral materials by both wind and water and the development of natural shore features must be better understood in order to solve the problems of shore erosion and the shoaling of channels.

Tides and Surges

The processes involved in the excitation of harbors and bay areas to surge or seiche must be understood if they are to be protected from the effects of tsunamis or seismic waves. Tides and other long waves, and their propagation onto and transformation in the shore regime will be studied. The study involves both basic and applied research on: the propagation, transformation, breaking, and run-up of long waves; the mechanics of tidal flow at inlets and estuaries; the design water levels resulting from such tides or long waves; and the forces or flows resulting from the impingement of these waves on shores and shore structures.

Inlet and Estuary Dynamics

The Corps will continue its research to obtain an improved understanding of inlet and estuary dynamics. The study of tidal hydraulic phenomena will be emphasized to find solutions to the problems of shoaling, bank erosion, pollution and flushing, particularly as these factors affect shipping areas and beaches used for recreation.

Environmental Data Collection

Ocean wave data will be collected, compiled, and analyzed in order to assess factors related to shore processes more adequately. Data at onshore locations will be used to make forecasts based on local hydrographic conditions. Offshore recordings of deep water wave data will permit the evaluation of previously obtained hindcasts and the verification of wave forecasts derived from meteorological data.

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Advanced Research Projects Agency

FY 1965—$525,000
FY 1966—$550,000
FY 1967—$700,000

Background

The Advanced Research Projects Agency (ARPA) has the responsibility for implementing Project VELA, which is concerned with the research, experimentation, and systems development needed to attain an adequate capability for detecting nuclear explosions underground and at high altitudes. The VELA UNIFORM Program, a major sub-project of VELA, is concerned with research and development to improve detection, location, identification, and verification of underground and underwater nuclear explosions. About 20 percent of this effort is conducted on the continental shelf.

Proposed FY 1967 Program

In FY 1967, those aspects of this program involving marine geophysics are reported for the first time in the National Oceanographic Program. In general, ARPA has implemented the VELA UNIFORM Program by delegating technical management of contracts to research and development organizations within the Departments of Defense, Commerce, Interior, and the Atomic Energy Commission. By means of contracts and grants through these agencies, ARPA intends to continue support of projects which will provide new geophysical information on seismicity, earth structure, microseisms, and hydroacoustic-seismic wave propagation characteristics in several oceanic areas of the world, particularly in the island-arc regions of the Circum-Pacific Seismic Belt.

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DEPARTMENT OF COMMERCE

Environmental Science Services Administration

FY 1965—$1,070,000
FY 1966—$1,186,000
FY 1967—$2,290,000

Background

On May 13, President Johnson submitted to Congress his Reorganization Plan No. 2 of 1965, proposing the consolidation of the Coast and Geodetic Survey, the Weather Bureau, and the Central Radio Propagation Laboratory to form the Environmental Science Services Administration. The plan became effective two months later on June 13th. ESSA's mission is to describe, understand, and predict the state of the oceans, the state of the upper and lower atmosphere, and the size and shape of the earth.

Within ESSA, the Weather Bureau participates in international meteorological and hydrological activities, and the Coast and Geodetic Survey conducts investigations, analyses, research, surveys, and disseminates data in the fields of hydrography and oceanography. The newly established Institute for Oceanography, however, will be responsible for the major part of ESSA's oceanographic research.

The Institute for Oceanography attempts to provide increased knowledge and better understanding of the ocean and its influences on or interactions with the total physical environment of the globe as required to improve ESSA's marine services. In carrying out this mission the Institute for Oceanography works closely with the other Institutes for Environmental Research of ESSA. Approximately 30 percent of the ESSA research program is conducted on the continental shelf.

Proposed FY 1967 Program

Sea-Air Interaction

This program was prepared by the Department of Commerce and reviewed by the ICO/ICAS Air-Sea Interaction Panel.

Emphasis will be on area studies in determining optimum locations for meso-scale air-sea interaction processes research. In addition, the use of models is planned for studies of: seasonal change of ocean currents in response to wind stress and related water-mass movements; effect of density structure and wind stress on abrupt shifts of the Gulf Stream and Kuroshio Currents away from shore in middle latitudes; and temperature distribution at the surface on total meridional heat transport in an enclosed basin. Mathematical

models of atmospheric and oceanic boundary layers will be developed from microscale studies.

In storm surge research data will be applied from idealized storms on a variable depth basis, and research on turbulent exchanges of momentum and heat will continue.

Land-Sea Interaction Research

Primarily this research is designed to provide fundamental information on the response of continental shelf sediments to applied static and dynamic forces in order to predict these responses. This is to be accomplished by the development of the process-response mechanisms in the natural environment, by the formulation of prediction equations, and by long-term environmental studies. The project will ultimately provide a series of equations to predict the behavior of all types of sediments under natural and artificial loads. It will also result in a computerized data acquisition and analysis system providing 24-hour forecasts of wind, wave, tide, current, and storm-surge effects on beaches and on estuarine and continental shelf sediments.

Marine Geology and Geophysics Research

Continental shelf geologic research primarily deals with the physiographic expression of the sea floor and its geologic interpretation. The objectives are: to describe the morphology of the continental shelves; to interpret the effects of sedimentary and tectonic processes on the continental shelf morphology; to predict morphological changes on the continental shelves; and to disseminate morphological data and geological interpretations for scientific and exploratory purposes. It is intended that this project be of a long-term and continuing nature.

Deep-sea-floor research investigations and subsequent evaluation of continental drift theory are the principal objectives of a separate project. Aspects of this project related to the continental shelves are the study of continental margin prisms and of the character of the ocean floor. These studies are oriented toward the geology of the earth's mantle (sea floor) as opposed to the geology of the earth's crust (continents).

Marine geophysical research activities are primarily investigations of the relationship of the continental margins to the growth of continents by accretion, continental margin tectonics, continental drift, and expansion of the earth. This research deals primarily with seismic refraction and reflection data and secondarily with geomagnetic and gravimetric studies.

Physical Oceanographic Research

Tide research investigations are exploiting the great volume of tidal data collected in previous years. These data will be analyzed for long-term cycles using computer techniques. The program will seek answers to fundamental questions of tidal propagation on the open ocean, long period variations of sea level, and the effect of fluctuating river discharges. The program will improve our ability to predict the rise and fall of tides so vital to navigation and safety in coastal waters.

Tsunami research is principally in the Institute for Oceanography's Joint Tsunami Research Effort (JTRE) at the Institute of Geophysics of the University of Hawaii. The primary objectives of JTRE are to measure and interpret tsunamis for improving the Seismic Sea-wave Warning System.

SEAMAP Research

The SEAMAP program's research component consists of studies oriented toward the interpretation and dissemination of the vast amount of oceanographic, hydrographic, marine geological and geophysical data generated by the ESSA work in support of the Ocean Survey Program. These activities are conducted at the Institute for Oceanography's Seattle Oceanographic Laboratory, with the Joint Oceanographic Research Group of the Institute for Oceanography at the University of Washington.

The overall objective of the program is the description and interpretation of the environment and structure of the North Pacific. Studies will attempt to determine the gross relationship of the distribution of properties and movement within the water mass, and of the interaction of the water mass with the sea floor. The problems of understanding and forecasting phenomena

such as the North Pacific Transition, Northeast Pacific Energy Budget, and the Alaska Current will also be investigated.

Maritime Administration

FY 1965—$50,000
FY 1966—$50,000
FY 1967—$50,000

Background

The objective of the Maritime Administration's oceanographic program is to improve our understanding of the nature of the ocean's surface and its effect on the operation and design of merchant ships.

During past years, considerable progress has been made in the development of theoretical and experimental techniques to study how ships respond to wave forces and how various ship characteristics effect these responses. But this is only a beginning. Much more data are needed in order to establish rational structural design criteria.

Proposed FY 1967 Program

Under a contract with the Massachusetts Institute of Technology, experimental and theoretical studies of ocean wave spectra and their effects on ship motion will be continued. Major emphasis of this research will be on the efficiency and safety of ship operations.

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DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY 1965—$11,771,000
FY 1966—$13,575,000
FY 1967—$14,345,000

Background

The mission of the Bureau of Commercial Fisheries is to carry out the national fishery policy adopted by the Congress, as follows:

(1) to increase and maintain forever, for the people of the United States, a fishery resource capable of yielding the maximum annual product;

(2) to strengthen and maintain a vigorous fishing industry;

(3) to perform these functions in partnership with the States,* and in accordance with our international obligations.

In order to carry out this mission the Bureau's Oceanographic Research Program is directed to understanding the dynamics of marine productivity.

It provides the basic information needed to predict fluctuations in abundance of fish populations, and to develop means for increasing production of fish and shellfish stocks. Research data are used to establish the United States' position on fishery matters of international concern and to protect and restore fishery resources essential to the livelihood of American fishermen. The Bureau's research program is increasingly providing the information needed by management and industry to obtain the full utilization of its fishery resources.

Proposed FY 1967 Program

A sizeable portion of the Bureau's program in basic research will be devoted to studies of the taxonomy, physiology, and behavior of fishes and marine invertebrates. Increased emphasis will be placed on determining factors causing mortality in fish and shellfish. Studies of the responses of marine organisms to environmental features, investigations of ocean productivity in relation to circulation and regions of upwelling, and programs designed to increase knowledge of air-sea interface processes will continue. A number of these and other basic studies will be carried out under contract to universities and non-governmental agencies.

*The Bureau of Commercial Fisheries has been delegated the responsibility for administering the Commercial Fisheries Research and Development Act of 1964 (Public Law 88-309; 78 Stat. 197). The purpose of the Act is to support research and development in the States that will conserve our fishery resources and strengthen the U.S. fishing industry. The Bureau estimates that Federal support in FY 1967 of research and development under the Act, that should be considered a part of the National Oceanographic Program, will total $1.5 million.

High Seas Fisheries

The oceans beyond the continental shelf contain living resources of a magnitude unsuspected even a few decades ago. Among these are the valuable tunas, swordfish, hake, anchovies, thread herring, saury, mackerels, squid, and deep water shrimp. Many of these fauna have a transoceanic distribution which is as yet incompletely defined. Some are caught only seasonally when their life histories and migratory regimes bring them into shelf or coastal waters.

The competitive position of the United States fisherman on the high seas must be improved by developing these and other resources if he is to survive the competition of foreign fishing fleets. Programs must be continued to determine the location and sizes of new fish populations and how these vary with changing conditions in the sea, to determine what ocean conditions bring about aggregations of fish and how these conditions can be predicted, and to find aspects of fish behavior that can be exploited to reduce the costs of catching fish.

A major factor preventing the full commercial exploitation of the protein resources of the sea is the general lack of application of our present scientific knowledge and engineering know-how. Studies will be continued to determine new methods of locating fish and harvesting them from the sea. Efforts to increase the efficiency of fishing operations will be accompanied by continued emphasis on maintaining stocks at their maximum sustainable yield. The United States has taken the lead in the world for proper management of the living resources of the ocean. To continue this leadership will require added emphasis on obtaining scientific data upon which management principles can be based. Research programs will continue on the life history, growth, mortality, subpopulations, migrations, and environmental requirements of important species in offshore waters. These studies in time will lead to information on what harvest the stocks might support on a sustained basis.

Continental Shelf Fisheries

Proper management of the coastal and estuarine environment to produce fish and shellfish at maximum sustainable yields is one of the most critical problems facing the Bureau today. Actual size of the habitat has been reduce by construction activity, and pollution has markedly changed the chemical and biological characteristics of the water. The effect of fishing on the inshore resources is not fully understood.

In working toward optimum use of the living resources of inshore regions the Bureau plans to continue emphasis on its radiobiological and pollution programs to determine the effects of pollutants on the marine environment. Research sponsored cooperatively by the Bureau of Commercial Fisheries and the Atomic Energy Commission will measure the existing levels of gamma radioactivity in the estuarine environment to find biological indicators of this radioactivity, and to determine what factors influence the accumulation and retention of radionuclides by filter-feeding fish and shellfish.

The Bureau will conduct studies at a number of coastal laboratories with the broad objective of eventually manipulating and managing the estuary to increase production of commercially valuable food organisms. Life history studies of important estuarine and coastal species will continue. Special emphasis will be given to: determining the causes of fluctuations in the size of fish and shellfish populations, developing selective strains and hybrids, and the application of fish cultural methods to fishing farming.

In estuarine studies of a different type the Bureau will continue to investigate the effects of engineering projects on biological productivity. Results so far indicate that sediments and biota do not return to normal condition within ten years after completion of certain types of dredge-fill projects. With proper knowledge of both the living resources and the environment, some estuarine waters already laid waste by man may be recovered.

In respect to dollar value, the No. 1 fishery product of the United States is shrimp, the greatest portion of which comes from the South Atlantic and Gulf coasts. The Bureau's shrimp research program is designed to determine the effects of environmental factors, such as salinity, temperature, light, and food on growth, survival and distribution. Studies will assess the effects of various fishing practices on shrimp populations and determine rates and causes of natural mortality.

BCF researchers will study the biology, ecology, and population dynamics of menhaden; the most important fish by volume of the U.S. commercial catch. One of the major objectives of this program is to aid the fishing industry by explaining the causes of fluctuation in the supply of menhaden.

In waters along our northeast coast, the Bureau will investigate the relationship between the Georges Bank herring stock and the Maine sardine. Biostatistical programs will be improved to allow rapid assessment of herring and groundfish stocks in order to provide the basic data for decision making on international management proposals by the U.S. Commissioners to the International Commission for the Northwest Atlantic Fisheries (ICNAF). Estimates of sustainable yield will continue to be calculated for the major groundfish species of concern to ICNAF. In this area, BCF will also continue its studies of the population structure, behavior, and ecology of the New England lobster, and the distribution and reproductive cycles of the surf clam.

The biology of the Pacific herring will be studied in southeastern Alaska to determine the effect of variations in spawning upon the catch, the origin of stocks, natural mortality, migration patterns, and life history of the species.

Basic environmental data will be collected in Alaskan waters and related to the commercial production of demersal fishes. Investigations will determine factors controlling the survival of pink and chum salmon. Extensive research will be conducted on the groundfish resources of the shelf off Washington and Oregon, mainly on hake, sable-fish, and ocean perch, to assemble information on migrations, reproduction, ecology, growth, mortality, distribution, and abundance in relation to environmental factors. A sampling program will be continued within the newly established commercial hake fishery.

The Bureau will investigate the biodynamics of sardines, anchovies, and other important marine fishes of the California coast. Serological techniques will be used to identify and delimit subpopulations of sardines and anchovies, and experiments will continue to learn more about their behavior. Research is also proceeding on the physiological functions and metabolism of fishes and other marine organisms, and on the transfer of energy through the food chain.

Bureau of Sport Fisheries and Wildlife

FY 1965—$401,000
FY 1966—$658,000
FY 1967—$638,000

Background

The growth of marine angling has intensified pressure on coastal fish resources and is changing the nature of conservation problems. Anglers, fishing within 20 miles of shore, catch 11.25 billion pounds of fish a year. It is within this coastal zone that the Bureau concentrates its game fish research. The BSF&W research program consists of: (1) life history studies of fish species to fill gaps in knowledge about distribution in space and time, age and rates of growth, identity and size of populations, migratory habits, food habits, reproductive seasons, enemies, parisites, and diseases; and (2) analysis of environments to identify and measure factors affecting distribution, movements, abundance and well-being of game fish species. All of the Bureau's research is conducted on the continental shelves.

Proposed FY 1967 Program

Research into the behavior, life history, and environmental factors related to the distribution of sport fish will be continued. A major effort centers on the bluefish, one of the important angling species of the Atlantic coast. The problem of distinguishing populations of bluefish is being attacked by several techniques including analysis of body proportions, growth rates, blood chemistry and parastic content. The Bureau will study the life histories of Pacific game and forage fishes, including the Pacific herring, greenling, rockfish, lingcod, anchovy, bonito, and barracuda.

Studies of the abundance, distribution, and dynamics of game fish populations, and the effects of man's activities upon them, will be continued. Variations in the survival of juvenile stages of fishes will be investigated, and a methodology will be developed to support a catch and effort sampling program.

Studies of the environment will be made in conjunction with surveys of the distribution of fish species to predict variations in occurrence

and abundance and to locate species during periods when scarcity results from lack of availability, or seasonal changes in distribution, rather than from depressed numbers.

Research will be started to provide a basis of scientific information for predicting the consequences to gamefish of the loss or reduction of estuarine areas. Studies of the basic nutrition cycle involving the estuaries and coastal regions will be emphasized to determine the mechanisms whereby the shallow water areas fertilize the bay and coastal areas.

One species of dinoflagellate can be used to measure and analyze certain factors involved in the biological productivity of sea-water. The experimental culture of microorganisms will be undertaken in order to improve techniques for estuarine bioassay.

Geological Survey

FY 1965—$581,000
FY 1966—$677,000
FY 1967—$679,000

Background

The mission of the Geological Survey requires investigations of marine geological, hydrological, and geophysical conditions, and processes in order to obtain knowledge that is needed by industry and others to find, develop, exploit, and conserve natural resources both on and beneath the ocean floor. The mission is being accomplished through basic research programs that have been underway for many years within the Survey and through systematic mapping and study of marine conditions and processes. Much of United States nondefense industry looks to the Geological Survey to provide the same technical expertise and leadership with respect to the seabed that it has historically provided on the land.

Proposed FY 1967 Program

Basic Studies

The Geological Survey will continue its research into aspects of marine geology and hydrology that relate to the origin, composition, structure, and history of the continental shelves and ocean basins. Areas of stress will be on the nature and distribution of volcanic rocks that form the ocean floor; the formation of marine sedimentary rocks and mineral deposits; the effects of freshwater and sediment discharge from land areas on adjacent marine environments; and the relationships of geologic, hydrologic, biologic, and geochemical processes within rocks and sediments to the properties and life forms of adjacent ocean waters.

Deep Ocean Exploration

Laboratory studies of ocean-floor samples and of data collected aboard ships of other agencies will be continued in order to gain knowledge of the distribution of elements in the earth's crust and of the composition of volcanic rocks, manganese nodules and other geologic material on the ocean floor. Geologic studies of oceanic islands, adjacent coral reefs, and of long cores from the islands and ocean floor, accomplished partly in cooperation with other agencies and with various institutions, will provide new knowledge that is needed to explain the distribution of existing biologic species and the origin and history of the ocean basin.

Continental Shelf

In collaboration with other government agencies and with oceanographic institutions, the Geological Survey will continue its program of geologic mapping of the continental shelves and slopes bordering the United States. The primary objective of this program is to provide a base for exploration, evaluation, and development of geologic resources. The mapping will provide information of direct applicability to ocean engineering, development of biologic resources, identification of earthquake hazards, defense, and recreational use of nearshore areas.

Emphasis of the reconnaisance investigations, which are now underway along the east coast, will be on completion of bedrock sampling, on laboratory investigations of material collected during previous years, and on the preparation of reports outlining results of the studies.

On the Pacific shelf, the Survey will continue its investigations of ocean-floor stability in sounds

along the earthquake-prone southeast Alaskan coast, in San Francisco Bay and elsewhere along the California coast. The studies of sea floor stability along the Alaskan and California coasts contribute to and are integrated with work designed to assess the geologic and hydrologic resources of bays and the offshore areas.

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NATIONAL SCIENCE FOUNDATION

FY 1965—$15,700,000
FY 1966—$22,000,000
FY 1967—$20,000,000

Background

The National Science Foundation's primary role in the National Oceanographic Program has been to support, by various means, research, facilities, and education at universities and oceanographic institutions. This participation in the government-wide program consists of:

(1) Funding ship construction and conversion.

(2) Supporting the construction of laboratory buildings, docking facilities, and other shore installations.

(3) Making basic research grants.

(4) Assuming responsibility for an appreciable part of the ship operating costs at educational institutions.

(5) Operating the U.S. Antarctic Research Program.

(6) Supporting special studies, fellowships, and conferences.

(7) Participating in the support of the National Oceanographic Data Center and World Data Center A.

(8) Funding most of the U.S. costs for the International Indian Ocean Expedition, part of the costs for the U.S. participation in the International Cooperative Investigations of the Tropical Atlantic and the Southeastern Pacific Oceanographic Program.

Support of oceanography in the Foundation can thus be categorized in five general areas: *Research, Facilities, Conferences and Studies, Science Information,* and *Education.*

Since oceanography is not a single discipline, it becomes inextricably entwined with the responsibilities of many organizational parts of the Foundation. Although most of the support comes from the Research Divisions (Division of Biological and Medical Sciences, the Division of Environmental Sciences, and the Office of Antarctic Programs), significant contributions are made by the Division of Institutional Programs, the Office of International Science Activities, the Office of Science Information Service, and the divisions concerned with education.

Since its beginning the Foundation has been involved in the support of oceanography, but the major growth in this support has been since FY 1958; that year NSF made approximately 80 grants in all aspects of oceanography at 38 universities and scientific institutions. Today, the Foundation sponsors well over 350 programs at 124 universities and institutions engaged in the study of the oceans and the Great Lakes. In FY 1958 institutions receiving NSF grants in oceanography were located in 20 states; present support is rendered to institutions in 34 states, plus Puerto Rico and the District of Columbia. During this same period, NSF support of senior research personnel rose from approximately 50 to more than 200, and support of graduate students through research grants, fellowships and traineeships has grown from less than 40 to over 160.

Realizing that the exploration and comprehension of the seas has been hampered by the lack of good research vessels and adequate shore facilities, the National Science Foundation has joined other agencies in an attempt to improve this critical situation. Since 1958, the Foundation has supported the conversion or the building of 12 major research vessels, plus numerous small boats, and the construction or remodeling of some 59 shore facilities. In seven years, more than $34 million has been used to fund ships and facilities. In addition to research and facilities, there has been an appreciable increase in the support of conferences, special studies, and the dissemination of scientific information and education. This has been accomplished by funding fellowships, traineeships, and teachers' institutes, as well as by other means. Over $1 million per year is now expended annually on these endeavors. Since FY 1958, a total of about $107 million has been expended in supporting approximately 1,600 research grants and contracts.

Proposed FY 1967 Program

NSF support of oceanography involves two broad areas of study: biological and physical. The oceanographic institutions receive support for research in these two areas primarily from the Division of Biological and Medical Sciences, the Division of Environmental Sciences, and the Office of Antarctic Programs. Over the past several years, there has been a special item in the budget for the International Indian Ocean Expedition. Funds for supporting this expedition have been essentially devoted to biological and physical oceanography in their broader sense.

Biological Oceanography

The Division of Biological and Medical Sciences has, in addition to the general support of biology, the specific task of funding in biological oceanography. This funding is made in support of seven programs: Developmental Biology, Environmental Biology, Genetic Biology, Metabolic Biology, Regulatory Biology, Systematic Biology, and Special Programs. It is handled in this manner as biological oceanography and differs from biology in no significant way; it is quite simply the biology of that part of our globe which constitutes the sea—the study of all life from shore to shore. As such, it spans the gamut of biology from the consideration of the biophysiochemical activities within parts of individual cells to the complex metabolic functions of cells and tissues, the physiological responses of organs, and the study of whole organisms, many of which display patterns of organization and development unrepresented elsewhere than in the oceans. The functions, locomotion, and behavioral traits of marine organisms include exotic and strange adaptations to the peculiarities of the aquatic environment, warm or cold, shallow or deep, bright or perpetually black, rich or poor in nutrients, crowded or open, clear or muddy, still or turbulent. The factors that govern evolutionary rates of change, dispersal of organisms, relationships between producers and consumers, predators and prey, and the organisms and their environment are often distinctly different in the sea from those on the land. Because of this difference, they require special study. Finally, the Foundation supports the investigation of the fantastically complex system that represents the integration of living organisms to the physical elements of the sea and the relationship of the sea to the atmosphere above.

The support of biological oceanography in the Division of Biological and Medical Sciences has shown a marked increase since 1958, the year selected as the base for all comparisons. The funding for research has gone from $765,000 to almost $5.8 million in FY 1965 with an approximate 2.6 fold increase in the number of grants. In FY 1967, the Foundation will continue to respond to proposals from investigators working in biological oceanography, with approximately $6,700,000 budgeted for this purpose.

Physical Oceanography

Physical aspects of oceanography are supported primarily within the Division of Environmental Sciences. Here, a specific program has been formed for administering the Foundation's oceanographic endeavors in physical oceanography. Since oceanography is not a single discipline, there is some contribution from the Geophysics Program on some phases of marine geophysics and from the Meteorology Program on air-sea interaction. However, the bulk of all university support by the Foundation in physical oceanography is conducted under a specific budget item for the Oceanography Program.

The study of the oceans as a physical entity has had a rather slow development in the United States, but finally it has attained stature within the scientific community and the vital role it plays in our welfare is now recognized. Physical oceanography, which embraces a number of widely divergent scientific investigations, is concerned with the water covering the earth's surface as well as the floor of the ocean basins, which the great depths have shrouded from our view. Investigations reach into the circulation of the oceans and the processes promoting the movement of water. Studies are conducted to determine the energy flow between the sea and the atmosphere. The formation and dissipation of waves and their energy is a perplexing problem to which the oceanographer is devoting much of his effort. The chemistry of water and the movement of

sediments, as they relate to the circulation and the nutrition and geochemical cycling of elements are other exciting fields of research. A major interest is in the sediments that are being continuously deposited on the ocean floor; in them are preserved, through varying mineral and fossil types, a record of the earth's history. And finally, researchers probe into the subbottoms of the oceans to determine their underlying structure and the history of the basins themselves.

The support of these and other facets of physical oceanography by the Environmental Sciences Division began to increase in tempo in about 1958, when $470,000 was expended in supporting 25 grants at oceanographic institutions. Since that time, there has been a tenfold increase in expenditures, and the number of grants made in FY 1965 has almost tripled the 1958 figure. $8,000,000 has been budgeted in FY 1967 to support investigators working in physical oceanography.

ANTARCTIC PROGRAMS

The National Science Foundation serves as the principal Federal agency for the development, coordination and management of all United States scientific activities in Antarctica. Since July 1962, oceanographic research has been conducted aboard the USNS ELTANIN in the area between about 50°S latitude and the edge of the ice pack.

ELTANIN provides the platform for high latitude research programs of many government agencies and universities in upper atmospheric physics, meteorology and all phases of oceanography. To date, the ship has worked the Scotia Sea and Drake Passage areas between South America and the Palmer Peninsula and has made several cruises in the South Pacific Ocean. Cruises have also been conducted between New Zealand and Chile and between New Zealand and the Ross Sea.

Research conducted aboard the vessel includes biology, hydrography, air-sea interaction, marine geology, and geophysical investigations. In addition to the shipboard operations, research on the materials and data collected aboard ELTANIN is supported at institutions throughout the United States.

The remarkable growth in oceanographic support by the Office of Antarctic Programs is evident by the fact that in 1958, only one grant was made for $2,000; by 1965, the 32 oceanography grants totaled more than $3 million. Of the total expenditures, about 47 percent was used to support biological oceanography and 53 percent for physical oceanography. This of course, includes the operational costs of the ELTANIN.

The work will continue in FY 1967, with a total of $2,300,000 budgeted for oceanographic studies in the Antarctic.

OCEAN SEDIMENT CORING PROGRAM

One of the Foundation's larger new efforts is an extended program of ocean sediment coring. This program is considered very important in the study of both the ocean and the solid crust of the earth.

The earth's crust beneath the oceans is not as well understood as the crust beneath the continent. Actual samples of this crust would yield data on many exciting scientific problems that could have practical significance. The extent of our knowledge today is such that we do not even know the age of the ocean basins. We do know that marine sediment rocks laid down in comparatively shallow water, and now consolidated into the continents, are as old as two billion years. Yet, the oldest samples we have been able to dredge from places in the ocean basins where recent deposits have been swept away are barely 100 million years old. We do not know whether the deep basins actually date from only about 100 million years or whether we just have not found older samples. Hopefully, core samples extending through the sediments may help answer this question.

Deep sediment drilling would also enable geologists to obtain a longer record of the earth's climatic history. By studying microfossil distribution and their O^{16}/O^{18} ratios, changing events could be determined by isotopic techniques. This would expand our knowledge of both long and short range climate cycles.

The origin, history, and structure of the continental margin, a feature that presently baffles most of our geologists and geophysicists, could be investigated in far greater detail. Studies on the continental shelf may result in the discovery of new mineral resources. Cores from the

shelf and slope may show large-scale movements of the ocean as it has invaded and retreated from the continents, and could make it possible to determine whether such changes are cyclic in nature. This program, like other NSF sponsored investigations, contributes in large measure to the Continental Shelf Program.

The Ocean Sediment Coring Program began in FY 1966 and will continue for a number of years. The Foundation is budgeting $1,500,000 in FY 1967 for this program.

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ATOMIC ENERGY COMMISSION

FY 1965—$3,703,000
FY 1966—$4,227,000
FY 1967—$4,598,000

Background

The Atomic Energy Commission's role in oceanography centers on the development, use and control of atomic energy. This is part of AEC's overall statutory function to provide for the common defense and security of the people of the United States and to protect the health and safety of the public—both important goals of the National Oceanographic Program. A major objective is to quantify and understand the risks so that man may more freely use atomic energy to obtain its many benefits. Seventy-five percent of AEC's oceanographic research is related to the environment on the continental shelves.

Biology and Medicine Program

Nuclear explosive tests, waste disposal operations, fixed and mobile nuclear reactors, special isotopic power applications, and research radiotracers may directly or indirectly introduce radioactivity into the marine environment. To understand the risks involved in these operations, it is necessary to be able to predict in a quantitative fashion, the time-space-biological distributions of radioactivity, the possible effects on the marine biotic processes, and the mechanisms and possible means and rate of return to man.

Once radioactivity gets into the marine environment it is subject to a wide range of physical, chemical, and biological influences. Some of these dilute and disperse the activity while others concentrate it, or affect its movement. In general, these influences are a function of the elements involved, the place and condition of the physical circulation pattern, the geochemistry of the local sea water environment, and the biota of the site in all its taxonomic variations, population dynamics, ecological relationships, and distributional patterns. The following program areas are supported under the Biology and Medicine Program in 42 different research projects at universities and institutions throughout the United States.

1. *Biological Uptake, Concentration, Distribution, and Effects of Radioactive Elements*

Studies of the uptake, concentration, distribution and redistribution of radioactive elements, and effects of these on marine biota, comprise a major segment of the total program. Studies of distribution and abundance of fish, shellfish, and other biota, some of commercial importance, are being conducted to define marine populations and to establish the ecological relationships as baselines for future assessments of change. Emphasis is placed on ecological studies of marine food webs to demonstrate and measure cycling of nutrients and trace elements. Studies include uptake, retention, and loss of individual or groups of elements by selected species of biotic communities in one or more trophic levels.

2. *Marine Sedimentation and Chemical Interactions*

Limited studies will be conducted on phase distributions of selected elements in the marine environment to determine sedimentation rates and exchanges with suspended and bottom sediments. Other studies of the distributions of naturally occurring radioactive elements such as carbon-14 are providing clues to the top-to-bottom ocean circulation rates. Studies of the composition and fate of terrigenous sediments provide information on the possible interactions with radionuclides and their translocation in the marine environment. Studies of partitioning of natural isotopes in the uranium and thorium

series provide information on mechanisms of formation and rate of deposition in oceanic sediments.

3. *Oceanic Circulation and Mixing*

Physical and chemical oceanographic studies relate directly or indirectly to the biological studies, *e.g.,* availability of nutrients to biota, trophic levels involved, and their location in the environment. These lead to a consideration of the original physical-chemical nature of the elements, the changes that occur when they are introduced in sea water and the subsequent influences of the environment on the element. In addition, study of the distributions of elements endemic to the marine environment assist in the determination of the dynamics of similar but artificially introduced elements, and also determine the carrier or specific isotopic dilutions that would be available for radioactive isotopes. A substantial effort is supported in determining the geographical distribution of fallout nuclides and their variation in concentration with depth. Direct studies of physical movements, such as circulation, diffusion and advection, are also conducted.

4. *Special Oceanographic Projects for Atomic Energy Operations*

This work comprises special *ad hoc* studies and assessments of Commission operations such as the marine distribution and effects of close-in and ultimate fallout from detonations of nuclear devices, or of radioactivity from other applications of nuclear energy and is conducted by universities and government agencies other than AEC. It also provides overall program counsel and guidance such as support of the advisory National Academy of Sciences Committee on Oceanography and of the data disseminated by the National Oceanographic Data Center.

Reactor Development Program

Oceanographic research is supported under the Reactor Development Program in the following projects:

1. *Studies of Factors Affecting the Dispersal of Fission Products in Estuarine and Coastal Environments*

This project involves (1) empirical and theoretical studies of the physical processes of movement and diffusion in the marine environment; and (2) evaluation of probable surface-layer concentration following a unit release of activity from nuclear source on the ocean floor. The work is performed at the Chesapeake Bay Institute, Johns Hopkins University, Baltimore, Maryland.

2. *Radionuclide Release to Sea Water from Nuclear Power Source Materials*

This project involves source term definition from nuclear isotopic power sources in the marine environment as a part of hazards assessment of SNAP devices. The work is performed at the U.S. Naval Radiological Defense Laboratory, San Francisco, California.

Isotopes Development Program

Research and development on the applications of radioisotopes to problems of national interest in the development of oceanographic resources will continue. Currently in progress or planned are projects for:

(1) Isotopic current meters to automatically record the direction and rate of movement of ocean currents;

(2) Isotopic devices for an *in situ* analysis of ocean sediments;

(3) Application of radioisotope methods and technology in recovery of mineral resources from the ocean;

(4) Radioisotope systems for shipboard analyses of the mineral content of cores from the ocean bottom.

Physical Research Program

The Physical Research Program supports research at several universities and laboratories in the following task areas: geological dating of corals and other calcareous marine and terrestrial materials; radiochemical and geochemical studies; radiochemistry as applied to geochemical problems; investigations of isotopic abundances of

such substances as strontium, calcium and argon in certain minerals; co-precipitation of metallic ions with calcium carbonate; and work on helium-uranium ratios for fossil shells and corals as related to geochronology and incidential study of ancient oceanic conditions and comparison with modern conditions. No project of the Division of Research is classified as oceanography *per se*; however, several projects in the areas described above are of indirect interest to several oceanographic research investigations.

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DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Public Health Service

Bureau of State Services

FY 1965—$1,100,000
FY 1966—$1,060,000
FY 1967—$1,083,000

Background

Oceanographic research in the Bureau of State Services is carried out in the division of Environmental Engineering and Food Protection and of Radiological Health. All work is conducted in support of the basic PHS mission, safeguarding the public health, and is conducted on the continental shelf.

Proposed FY 1967 Program

Division of Environmental Engineering and Food Protection, Shellfish Sanitation Branch

This program is concerned with the public health suitability of foods derived from water and with the effects of marine organisms or their byproducts on man. Some research is sponsored at universities. In-house research is performed at shellfish sanitation research centers at Dauphin Island, Ala.; Narragansett, R.I.; and Purdy, Wash. In FY 1967, studies will be continued on the fate of pathogenic organisms (including viruses) in estuarine waters and on the accumulation of suspended, colloidal, dissolved, and radioactive pollutants by shellfish, with emphasis on pesticides and other toxic (to humans) materials, and industrial wastes. Studies of paralytic shellfish poison will be continued on the Atlantic and Pacific coasts, with emphasis on ecology and laboratory essay procedures. On the Gulf Coast, laboratory and ecology studies will be continued on neurotoxins associated with the "Red Tide." Techniques for laboratory identification of Type E botulism organisms, commonly associated with sea food, and their estuarine ecology, will be developed. Studies will be continued on the identification of marine substances which inhibit the growth of human disease or of cancer producing organisms. Limited studies will be initiated on the potential transmission of human disease-causing organisms by sea birds.

Division of Radiological Health

Through research contracts to institutions, the Division will continue investigations into the fate of radioactive materials in the marine environment, and their effect upon man.

National Institutes of Health

FY 1965—$1,940,000
FY 1966—$2,100,000
FY 1967—$2,250,000

Background

Biomedical scientists supported by the National Institutes of Health (NIH) ask fundamental questions of vital importance to human biology and seek the answers wherever they may be found. Basic biological phenomena frequently prevail among many, or even all, living things. Some of these phenomena can be studied more readily in the simpler structures of marine invertebrates than in the complex structures of mammals commonly used as experimental animals.

It is clear that, in terms of NIH programs, marine biology is not of itself a discipline, but that the use of marine forms contributes to research in many of the biomedical disciplines, such as physiology, biochemistry, genetics, microbiology, developmental biology, and the behavioral sciences. In the evolution of NIH programs, it is not the purpose of the Institutes to

develop marine biology *per se*, but rather to afford opportunities for biomedical scientists to become aware of the unique features of marine organisms and to provide them access to those forms best suited to their research programs. The facilities for such access are therefore an important concern to NIH programs.

Oceanographic research grants are supported for the most part by the National Institutes of General Medical Sciences, Neurological Diseases and Blindness, and Allergy and Infectious Diseases. However, others are supported by the Institutes of Arthritis and Metabolic Diseases, Cancer, Dental Research, Child Health and Human Development, Heart, and Mental Health.

Proposed FY 1967 Program

The NIH effort involves work on marine algae and higher plants, microbes, invertebrates, chordates, and vertebrates (including birds and mammals). Research will be in the following subject areas:

- Cellular physiology
- Developmental biology
- Endocrine physiology
- Cardiovascular physiology
- Neurophysiology
- Psychophysiology
- Vertebrate and invertebrate behavior
- Genetics
- Population dynamics
- Evolutionary development of proteins (*e.g.* hemoglobin, immune globulins)

Federal Water Pollution Control Administration

FY 1965 – $1,405,000
FY 1966 – $1,499,000
FY 1967 – $2,033,000

Background

Activities conducted by the Division of Water Supply and Pollution Control, Public Health Service, were transferred to the Federal Water Pollution Control Administration, an agency established within the Department of Health, Education, and Welfare, under the Water Quality Act of 1965. The Administration will carry out the oceanographic research activities related to water pollution control previously conducted by the Public Health Service. The Administration's entire research program is conducted on the continental shelf. (For comparison purposes the oceanographic research funding of the Division of Water Supply and Pollution Control in Fiscal Years 1965 and 1966 listed above has been broken out of the Public Health Service budget.)

Proposed FY 1967 Program

Research, as with other program components, is concerned with oceanographic activities as they relate to the water pollution control mission of the Administration. It consists of both intramural (in-house plus contract) and extramural (grant-supported) programs. Studies on the sources and fate of pollution disposed into coastal waters will be conducted at the marine sub-station at Newport, Oregon, in conjunction with the program of the Pacific Northwest Water Laboratory at Corvallis, Oregon. The National Marine Water Quality Research Laboratory at Narragansett, Rhode Island, when completed, will conduct research on identification of wastes and water quality requirements for fish and aquatic life and recreational, industrial, and agricultural uses. Extramural research will continue to be supported by universities and other institutions receiving Federal Water Pollution Control Administration grants.

U.S. Office of Education

FY 1965 – $ 77,000
FY 1966 – $165,000
FY 1967 – $264,000

The Office of Education is manager of Title 4 of the National Defense Education Act. The Office estimates that in FY 1967, new and continuing fellowships granted under this Act for the marine sciences will total about $264,000. This money will help finance the graduate education of worthy students as well as support, to a lesser degree, departmental expenses (in the university) incurred in providing instruction and facilities. In FY 1965, two students were supported at Johns

Hopkins University, one at Texas A & M, seven at the University of Rhode Island, and four at the University of Miami.

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DEPARTMENT OF THE TREASURY

Coast Guard

FY 1965—$60,000
FY 1966—$61,000
FY 1967—$65,000

Background

The goals of the Coast Guard research program are: to improve the services of the International Ice Patrol, further reducing the ice hazards to shipping in the North Atlantic; to develop a technique of accurately forecasting survivor drift at sea; and to support research efforts of other Federal agencies and private institutions with resources that only the Coast Guard can provide.

FY 1967 Program

Research into the origin, drift, and attrition of icebergs will continue. Qualitative and quantitative studies of the drift and deterioration of river, sea, and glacier ice will be performed, and time-series studies of short term changes will be made to improve forecasting. Quantitative descriptions of major ocean currents in the North Atlantic and North Pacific Oceans will be prepared from data obtained in the standard section survey program.

The formation and movement of water masses in the northern hemisphere will be studied through utilization of data provided by observations at fixed ocean stations, opportunity programs conducted by icebreakers, and special cruises by EVERGREEN.

Continental Shelf

During FY 1967, the Coastal Oceanography Section of the Coast Guard Oceanographic Unit will continue its oceanographic research work from the existing network of Coast Guard near shore fixed stations. It will design a time-series program in the littoral and sub-littoral areas of the continental shelf to determine gross features of the environment, seasonal changes, long and short term variations, and the effects of storms, droughts, and sudden changes in the geophysical environment. A system will also be developed for predicting changes in the coastal environment to support Coast Guard search and rescue, aids to navigation, and law enforcement missions. Actual data collection activities are funded under the "Surveys" category.

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SMITHSONIAN INSTITUTION

FY 1965—$ 795,000
FY 1966—$1,301,000
FY 1967—$1,597,000

Background

The mission of the Smithsonian Institution in oceanography is to carry out basic investigations of marine populations and distributions of organisms and sediments in the ocean. The Institution, through its responsibility to insure that the national collections are studied, maintains close liaison and direct coordination with many universities and government agencies. It provides assistance and support to international programs such as the International Indian Ocean Expedition, as well as to national programs such as the U.S. Antarctic Research Program and other expeditionary efforts. Its 50 marine scientists carry out and participate in the planning and field operations of biological and geological expeditions, and report upon the results of their studies of collections obtained on these expeditions. The Smithsonian Oceanographic Sorting Center processes specimens and sediments collected by and for oceanographic institutions, other government agencies, and the research staff of the U.S. National Museum. Smithsonian Institution's studies will result in an improved understanding of the kinds and abundance of organisms in the ocean, so that populations worthy of exploitation can be better selected. The descriptive studies of the Smithsonian are basic to the biological programs of all agencies and often are carried out in cooperation with them. Approximately 35 percent

of the Smithsonian's research program is conducted on the continental shelf.

Proposed FY 1967 Program

Biological and Geological Research and Services

This program is a continuation of research into the nature of the living and non-living particles in the oceans and sediments. Also to be continued are studies of the evolution and development of living marine populations, the storage and exchange of energy in marine ecosystems, and the history of the ocean basins as related to the development of explanations of existing life patterns and prediction of the life forms on other planets. Archeological studies of underseas sites will be undertaken on a limited basis. A specimen processing center receives and sorts biological and geological collections and makes them available to scientists for research. In order to carry out this program a small marine operations center is maintained.

Oceanography in Foreign Currency Countries

As a new oceanographic effort in FY 1967 the Institution proposes to undertake mutual research and service operations with those countries on the excess foreign currency list. These currencies have accrued to the United States government in amounts in excess of normal requirements, and the U.S. has agreed to use them in the nation of origin on projects approved by both the U.S. and foreign government concerned. Within its traditional and historic interests in specimen oriented research into the kinds, distributions, and populations of organisms in the world ocean, the Institution proposes to use its existing capabilities in cooperation with excess currency countries to study organisms and sediments in the seas adjacent to such countries.

In cooperation with the Food and Agriculture Organization of the United Nations and with the Mediterranean Association for Marine Biology and Oceanography, the Institution proposes to study basic problems of the distribution of marine organisms. Recent changes in salinity in the Suez Canal and adjacent waters have permitted an invasion of Mediterranean waters by Indian Ocean species. These species may upset the life patterns of people along the shores of the Mediterranean and thus have great potential interest. Additionally, the Institution expects to gain knowledge of great value in predicting the effect of a sea level canal across the middle American isthmus.

One or more specimen processing centers similar to and cooperative with the Institution's presently highly successful Oceanographic Sorting Center will be developed and operated in a foreign currency country. These will provide a capability for engaging in collection oriented research efforts in the Mediterranean Sea and in the Atlantic and Indian Oceans.

Construction of the Aswan Dam will change the flow pattern from the Nile River into the Mediterranean Sea. Funds from the foreign currency program are expected to contribute to an understanding of the mechanisms of this change as it effects the Eastern Mediterranean.

* * *

DEPARTMENT OF STATE

FY 1965—$432,000
FY 1966—$488,000
FY 1967—$476,000

Background

The Department of State supports work conducted by eight international fisheries commissions of which two, the Inter-American Tropical Tuna Commission and the International Pacific Halibut Commission support oceanographic fisheries research programs. The U.S. share of FY 1967 funding of these two Commissions is reported (above) to the Interagency Committee on Oceanography.

Proposed FY 1967 Program

Inter-American Tropical Tuna Commission

The Inter-American Tropical Tuna Commission is directed to conduct scientific investigations required to understand the biology and ecology of tropical tunas and tuna-bait fishes of the eastern Pacific and the effects of both natural factors and

human activities on the abundance and harvest of these fish.

Research is directed toward understanding the population structure of each tuna species and to identifying separate unit stocks. Studies will be continued to determine the feeding habits, schooling behavior, depth and area stratification, spawning, rates of growth, and migrations. It has been amply demonstrated that the distribution and behavior of the tunas is intimately related to environmental factors. Research, therefore, will be conducted on the circulation of the ocean, and the distribution of its physical, chemical and biological properties and the relationship of these factors to changes in abundance, distribution, and availability to capture of the tunas.

International Pacific Halibut Commission

The convention between the United States and Canada for the preservation of the halibut fishery of the North Pacific and Bering Sea was established to investigate the depletion of the Pacific halibut fishery, and to make recommendations for its restoration.

Joint scientific management by the United States and Canada over the past 35 years has rebuilt the once depleted fishery. However, pressures on the fishery caused by the expanding Japanese and Soviety trawl fisheries in the Gulf of Alaska, can only be mitigated through the use of up-to-date and reliable scientific data showing the exact extent of the halibut resource and the harmful effect of intensive foreign fishing upon it.

In FY 1967 the Commission will continue its statistical studies to measure the available supply of halibut on the grounds and to determine the extent of the yields taken from the various stocks. Age composition and growth studies will be made to ascertain the changes that occur within the stocks brought about either by the fishery or by natural forces of the environment. One of the Commission's most valuable research tools, the tagging program, will provide information regarding intermigration among the various stocks, their seasonal availability, and their natural and fishing mortality rates.

II. GEOGRAPHICAL EXPLORATION

Oceanographic Surveys

The FY 1967 survey program has two major operational components:

A. Traditional Historic Surveys comprise the Navy's military surveys; the Environmental Science Services Administration's nautical charting and tidal and current surveys; Federal Water Pollution Control Administration water quality surveys; and Bureau of Commercial Fisheries exploratory fishing and ground-fish surveys. These surveys constitute by far the largest percentage of the total Federal marine survey effort.

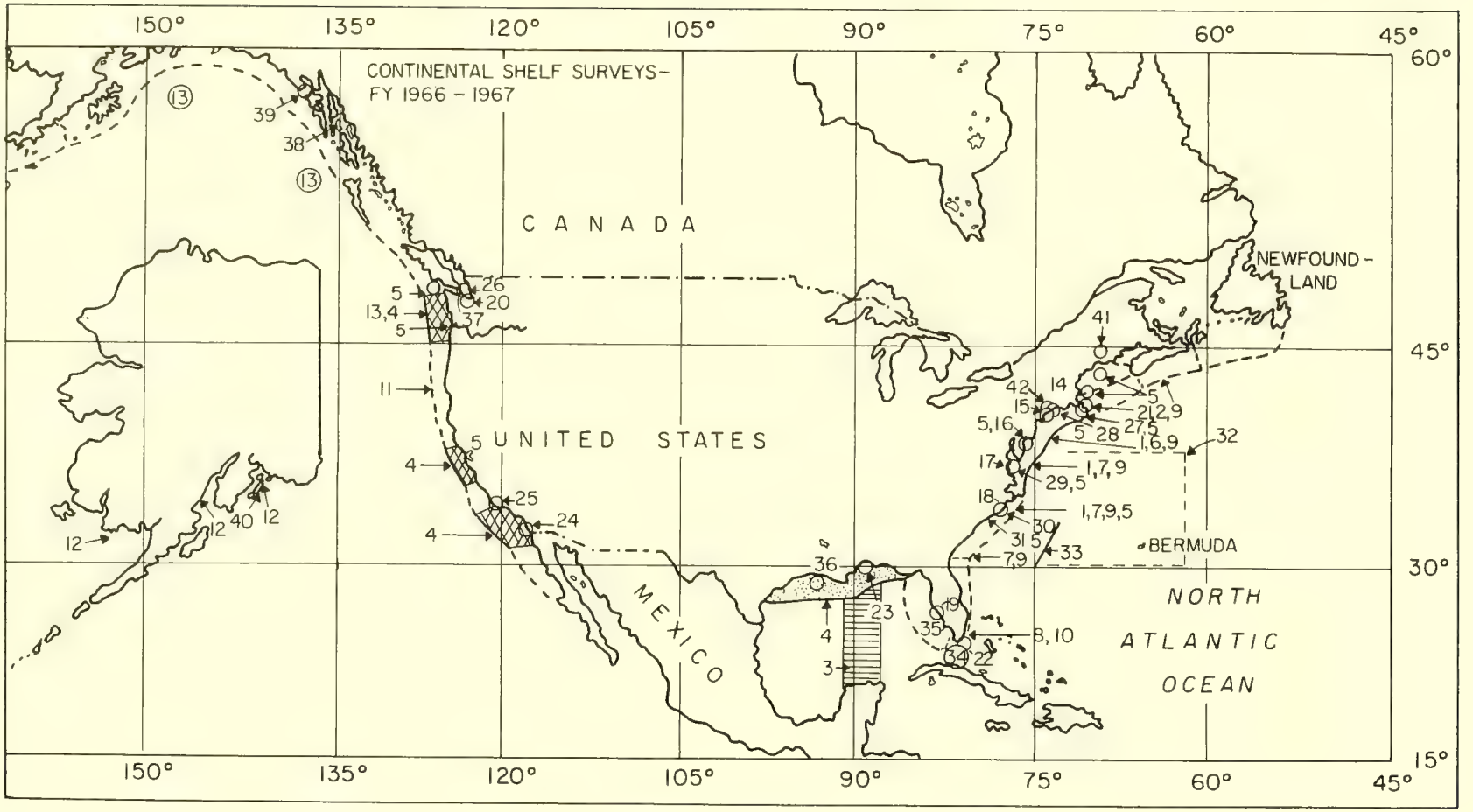
B. Scientific Exploration and Mapping Program (SEAMAP) consists of ocean-wide surveys of the type proposed by the National Academy of Sciences Committee on Oceanography (NASCO). The basic reasons for a systematic oceanographic survey of the world ocean have been spelled out in Chapter 9 of the NASCO Report and have been put in an operational framework by ICO Pamphlet #10, *Oceanography: The Ten Years Ahead.* Whereas traditional surveys are analogous to tactical operations aimed at near-term pay-offs, the newly identified Scientific Exploration and Mapping Program is analogous to strategic operations. It is aimed at longer-term payoffs to assure more effective tactical programs of the future. Progress on the program to date has been slow, although the program has the support of the non-governmental oceanographic community and the Interagency Committee on Oceanography.

The survey programs of the Navy, Environmental Science Services Administration, Geological Survey, and Coast Guard, contribute directly to project SEAMAP. Part of the data collected on the Bureau of Commercial Fisheries EASTROPAC program and on the Bureau of Sport Fisheries and Wildlife survey program will also contribute to the project. The Smithsonian Institution will cooperate by having specialists aboard ships of other agencies and by processing samples.

Both the traditional and the SEAMAP survey efforts are conducted on an ocean-wide basis. Both are important in exploring the air-sea interface, the water column, and the continental shelves and ocean basins beneath. The total planned funding for both survey components is shown in Table D.

Table D
BALANCE OF SURVEY EFFORT
(in thousands of dollars)

	Traditional Historic (mission oriented) Surveys		Scientific Exploration and Mapping Program	
	FY 1966	FY 1967	FY 1966	FY 1967
Navy	$15,336	$15,101	$ —	$ 7,110
ESSA	7,972	9,214	2,626	2,156
BCF	1,654	1,787	—	—
BSF&W	38	38	—	—
GS	—	—	15	15
PHS	130	167	—	—
FWPCA	699	1,470	—	—
CG	200	200	873	1,183
TOTALS	$26,029	$27,977	$ 3,514	$10,464



Locations of Continental Shelf Survey Operations

LOCATIONS OF CONTINENTAL SHELF SURVEY OPERATIONS
FY 1966–FY 1967

I. Coast Guard

1. Cooperative IRT flights for Sandy Hook Marine Laboratory (BSF&W)
2. Cooperative bottom temperature study on fishing grounds (BCF)
3. Cooperative IRT flights for Gulf Coast Research Laboratory (ONR)
4. Cooperative IRT flights for Tiburon Marine Laboratory (BSF&W)
5. Coast Guard Fixed Oceanographic Stations

II. Army Corps of Engineers (CERC)

6. Offshore sand survey–FY 1966
7. Offshore sand survey–FY 1967
8. Offshore sand survey–FY 1966

III. Geological Survey

9. East Coast sedimentological survey–FY 1965-66
10. East Coast sedimentological survey–FY 1967
11. West Coast offshore surveys–FY 1967
12. Alaskan surveys–Central & S.E. Alaska

IV. Bureau of Commercial Fisheries

1,2. Gloucester, Mass., Exploratory Fishing, Center. Surveys to investigate bottomfish, lobster, and shellfish populations.

3,7,9. Brunswick, Ga. Center–Surveys to determine shrimp and scallop distributions.

4. Pascagoula, Miss., Exploratory Fishing Center. Shrimp, tuna, and other finfish surveys, Gulf of Mexico and Carribean.

13. Seattle, Wash., Exploratory Fishing Center. Surveys on groundfish, hake, anchovy, and shrimp.

V. Bureau of Sport Fisheries and Wildlife

9. Abundance, distribution, and dynamics of gamefish.

VI. Federal Water Pollution Control Administration–Water quality and waste disposal studies

14. Hudson River–FY 1966-67
15. Raritan Bay–FY 1966-67
16. Delaware Estuary–FY 1966-67
17. Chesapeake Bay–FY 1966-67
18. Charleston Harbor–FY 1966-67
19. Tampa Bay–FY 1967
20. Puget Sound–FY 1967

VII. Naval Oceanographic Office–Survey operations in the vicinity of:

21. Newport, R.I.–FY 1965-66
22. Key West–FY 1965-66
23. Pascagoula, Miss.–FY 1965-66
24. San Diego, Calif.–FY 1965-66
25. Port Arguello, Calif.–FY 1966-67
26. Hood Canal, Wash.–FY 1965-66

VIII. Environmental Science Services Administration–Survey operations, field season, FY 1966-67

27. Nantucket Sound
28. Long Island Sound
29. Chesapeake Bay
30. Long Bay, N.C.
31. S. Carolina Coast
32. Upper Mantle Project 35°N 39°
33. Gulf Stream–Atlantic Ocean
34. Straits of Florida
35. Ft. Meyers, Fla.
36. Galveston Bay, Texas
37. Puget Sound
38. Keku Strait–S.E. Alaska
39. Glacier Bay–S.E. Alaska
40. Prince Wm. Sound, Alaska

IX. Public Health Service–Shellfish Sanitation

41. Medomak River, Maine–FY 1965-66
42. Oyster Creek, N.J.–FY 1966-67

Continental Shelf Surveys

The Continental Shelf Survey Program developed by the ICO Survey Panel will be integrated into an overall interagency continental shelf exploration and exploitation effort. This program will provide information on the basic physical, chemical, and biological processes necessary for the scientist and engineer working on the shelf. Its primary objectives are to delineate the scientific and economic potential of the shelf and of the water above it. This is accomplished through systematic surveys of the essential oceanographic variables, the biological content of the ocean waters, and the sediments of the ocean floor. Survey operations on the continental shelf are both of the SEAMAP and of the historical type.

Of the nine ICO agencies engaged in survey operation, five have survey missions which are concerned chiefly with the continental shelf. Thus, the work of the Public Health Service, Federal Water Pollution Control Administration, Geological Survey, and Bureau of Sport Fisheries and Wildlife is devoted to the phenomena of the nearshore and shelf regions. The Army Corps of Engineers also conducts continental shelf surveys along the Atlantic Coast in search of sand deposits for use in its beach restoration and erosion control work. Army surveys, however, are funded under Research and are not listed separately in the Survey program. The four remaining agencies—Coast and Geodetic Survey, Navy, Bureau of Commercial Fisheries, and Coast Guard—contribute to the general pool of shelf information as part of their broader survey missions throughout the world. The combined efforts of these agencies produce a significant amount of basic information on the environments of this scientifically and economically important portion of the ocean.

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DEPARTMENT OF DEFENSE

Department of the Navy

Naval Oceanographic Office

FY 1965—$14,704,000
FY 1966—$15,336,000
FY 1967—$22,211,000

Eleven ships of the Naval Oceanographic Office will operate in the Atlantic and Pacific Oceans during FY 1967 collecting oceanographic data. Airborne geomagnetic surveys and aerial Arctic ice reconnaissance will be continued. Although ship operations are primarily directed toward military requirements, a considerable portion of the data collected will be deposited in the National Oceanographic Data Center in support of the Scientific Exploration and Mapping Program (SEAMAP).

Another significant contribution to the SEAMAP Program will be made by the Navy's Marine Geophysical Surveys. These surveys, conducted by private U.S. industrial firms under contract to the Navy, are primarily designed to acquire oceanographic and geophysical data in strategic areas in both the Atlantic and Pacific Oceans to enhance Navy readiness. As a secondary objective, the data will provide information to the research scientist to further increase his understanding of the sea. Survey results are expected to yield scientific information that can be used to solve a number of important oceanographic and marine geophysical problems. Data colleced will be helpful in studying the problems of nutrient cycles and in solving many basic fisheries research problems as well as those related to studies of the productivity of the sea.

Also of benefit to SEAMAP will be the Navy's Anti-Submarine Warfare—Undersea Warfare (ASW-USW) Oceanographic Survey Program which is designed to provide ocean environmental information on a broad scope over wide ocean areas for support of Navy ASW-USW operations. This multi-purpose survey program will also provide scientists with an environmental model of the oceans which will add to the biological, geological, oceanographic and geophysical data needed for future exploration of the natural resources of the ocean and sea-bed beneath.

Ship Operations

Atlantic Ocean

SAN PABLO and SILAS BENT will operate in the North Atlantic carrying out oceanographic and bathymetric operations in support of the ASW-USW Oceanographic Survey Program. SHELDRAKE and KELLAR will operate in the North

Atlantic conducting bathymetric survey operations. LITTLEHALES will conduct limited acoustic and oceanographic surveys in the Tongue of the Ocean. Contract vessels ARCTIC SEAL and ATLANTIC SEA, will operate in the North Atlantic and Mediterranean in support of the Marine Geophysical Survey Program, and TOWHEE will conduct bathymetric surveys in the North Atlantic. Navy airborne magnetic surveys will continue with primary effort directed toward SEAMAP surveys. The aerial ice reconnaissance program in the Arctic will continue as in past years.

Pacific Ocean

REHOBOTH and KANE will operate in the North Pacific conducting oceanographic and bathymetric surveys in support of the ASW-USW Oceanographic Survey Program. KANE, scheduled for delivery in December 1966, will operate in the North Pacific conducting oceanographic and bathymetric programs. BERTHA ANN and SEA SCOPE, Marine Geophysical Survey contract vessels, will conduct oceanographic operations in the Pacific Ocean, and the Navy will contract for two additional vessels to augment these surveys during this fiscal year.

Continental Shelf

Recent operations on shelf areas adjacent to Key West, Newport (Rhode Island), San Diego, and the Hood Canal (Puget Sound), have contributed to the general pool of shelf information. Surveys now underway will be in areas adjacent to Pascagoula (Mississippi), Key West, and Port Arguello (California). FY 1967 plans call for continuing the Port Arguello survey.

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DEPARTMENT OF COMMERCE

Environmental Science Services Administration

Coast and Geodetic Survey

FY 1965—$ 8,827,000
FY 1966—$10,598,000
FY 1967—$11,370,000

Coastal nautical charting surveys, the current surveys, and the tidal program are all part of the traditional mission-oriented surveys of the Environmental Science Services Administration (ESSA).

ESSA's new ships, OCEANOGRAPHER and DISCOVERER will be delivered in FY 1967. Although the laying up of PIONEER removes from service the only ship that has devoted full time to Project SEAMAP, the assignment of OCEANOGRAPHER and DISCOVERER to SEAMAP will constitute a major step in the prosecution of this program. Furthermore, with the availability of the Navy Navigation Satellite System, the operation of SEAMAP survey ships at sea will no longer be limited to areas of Loran-C coverage.

Ship Operations

Atlantic Ocean

WHITING, HYDROGRAPHER, and MT. MITCHELL will make hydrographic and oceanographic surveys on the continental shelf. In the same area EXPLORER, PEIRCE, OCEANOGRAPHER, and DISCOVERER will operate, at least in part, on the continental shelf. They will perform geomagnetic as well as hydrographic and oceanographic surveys. DISCOVERER will operate on a trans-Atlantic underway section for Project SEAMAP. MARMER will conduct current surveys on the continental shelf. It will operate in Block Island and Long Island Sounds, and then progress southward.

HILGARD, WAINWRIGHT, RUDE, and HECK will carry out wire drag operations in the Florida Keys and Chesapeake Bay.

Pacific Ocean

OCEANOGRAPHER, after it completes its SEAMAP operations in the Atlantic, will be transferred to the central Pacific. SURVEYOR will operate in the North Pacific to complete the surveys of the area between the Aleutians and the Hawaiian Islands (SEAMAP).

PATHFINDER will continue its nautical chart surveys in the Hawaiian Islands and in Cook Inlet, Alaska. Eight other ships will also conduct nautical charting operations off the coast of Alaska. They are: BOWIE, HODGSON, LESTER JONES, PATTON, McARTHUR, DAVIDSON, FAIRWEATHER, and RAINER.

Continental Shelf

ESSA is cooperating with the Navy, Bureau of Sport Fisheries and Wildlife, Coast Guard, and five oceanographic institutions sponsored by NSF and ONR in a joint long-term systematic study of the Gulf Stream.

The seaward extension of the Upper Mantle Project Transcontinental Geophysical Survey will be carried some 500 miles offshore between 35° and 39° North off both the Atlantic and Pacific coasts. The inner portions of this work will be strictly continental shelf work and will be accomplished during the next two years.

Four ESSA vessels will continue to make new surveys of the shelf for the revision of various chart services. One is working in an area off Florida where surveys with continuously recording echo sounders have never been made in a systematic manner. The surveys are designed to disclose marine hazards and submarine topography for navigational purposes. These surveys will be of great value to marine geologists and others concerned with the scientific and exploration aspects of the shelf. However, they are biased to the shoal water side because of the relatively greater importance to shipping of precise delineations in those areas.

ESSA is concerned with the description of the continental shelf as an integral part of this continent which can and must be exploited. The program in ocean studies includes work in estuaries, on the shelves, and in the deep oceans, where the basic interest is to expand our understanding of these regions, rather than to furnish data strictly for nautical charts. These two programs, the Nautical Charting and Ocean Studies effort, are obviously complementary. Both contribute to the research effort of the ESSA Institutes for Oceanography and Atmospheric Sciences, as well as to the general fund of data available to the oceanographic community.

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DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY 1965—$1,445,000
FY 1966—$1,654,000
FY 1967—$1,787,000

The Bureau of Commercial Fisheries will continue its traditional, biologically-oriented survey programs to produce information used in mapping the distribution of the living resources of the sea and the physical characteristics of the environment. Projects for FY 1967 include exploratory fishing surveys, sea surface temperature and ecological studies, production of a faunal atlas of the continental shelf, tuna assessment surveys, distribution studies of bottom fauna, pelagic fishes, and invertebrates in the western Atlantic, Gulf of Mexico, and eastern Pacific. Hake resources off the West Coast will be assessed, and major participation is planned in the EASTROPAC survey in the tropical Pacific.

EASTROPAC is a proposed cooperative oceanographic study of a selected portion of the eastern tropical Pacific. Its purpose is to obtain fundamental information on the physical, chemical, and biological features of this region that will provide a background for further and more detailed research, provide a basis for increasing the harvest of the west coast tuna fisheries, and aid in forecasting weather. The program is being sponsored by the Eastern Pacific Oceanic Conference and will have the support of Scripps Institution of Oceanography, the Inter-American Tropical Tuna Commission, and other universities and agencies. It is likely that Ecuador, Peru, Chile, and Columbia will participate. Some of the data from the EASTROPAC Survey will contribute to the SEAMAP Program.

Continental Shelf

Explorations to assess the marine fishery resources outside of known fishing areas will continue off the southeast coast of the United States. Shrimp off the Georgia and Florida east coast and scallops off Florida and the Carolinas will receive particular attention.

Seasonal distribution patterns and abundance levels for bluefin tuna and swordfish will be determined for previously unexplored areas. An expanded tuna assessment program will be initiated to define the geographic and seasonal movements of these fish along the Atlantic coast in relation to environmental factors. An extensive program will be conducted to delineate the areal and seasonal variations in abundance and availability of the surf clam. Studies will be made of the

general distribution of bottom fauna, pelagic fishes, and invertebrates in the western Atlantic and Gulf of Mexico.

Work will continue on an atlas of fishing resources of continental shelf regions. Although the field sampling aspects of the cooperative study of the geology and benthic fauna of the shelf, being conducted jointly by the Woods Hole Oceanographic Institution, Geological Survey and BCF, has been completed, work will continue in BCF on analysis of collections and preparation of reports for publication.

Assessment of the hake resource will be expanded to cover the Pacific coast from Vancouver Island to Baja California. Surveys of the general distribution of bottom fauna, pelagic fishes, and invertebrates in the eastern Pacific will continue.

In cooperation with the Oregon Fish Commission and the Washington State Department of Fisheries, surveys will be made to determine the distribution and abundance of scallops in Pacific Northwest waters. Utilizing bottom trawls, longlines, and sunken gillnets, along the edge of the shelf over a depth range of 200 to 500 fathoms, BCF will try to determine the availability of deep water populations of sablefish. In cooperation with the AEC, benthic fauna surveys will be conducted along an established trackline on the shelf and slope off the Columbia River over a depth range of 25 to 1050 fathoms.

Bureau of Sport Fisheries and Wildlife

FY 1965—0
FY 1966—$38,000
FY 1967—$38,000

The Bureau's entire survey program will be conducted on the continental shelf. In cooperation with the U.S. Coast Guard, monthly surveys of sea-surface temperature with airborne infrared thermometers will be continued and will contribute to SEAMAP. During FY 1967 the project will be expanded to include the continental shelf area of the coast from the Straits of Juan de Fuca to the Mexican border. Surface currents in the above areas will be determined by dropping drift cards from the aircraft during the temperature flights. Bottom current studies will be undertaken in selected areas by use of Woodheat sea-bed drifters. Game and forage fish off central and southern California will be surveyed by fish spotter aircraft.

Geological Survey

FY 1965—$15,000
FY 1966—$15,000
FY 1967—$15,000

Funds include only those intended for the support of Geological Survey personnel taking part in oceanographic survey operations on ships of other agencies and for the geological equipment to be used aboard those ships. All surveys are conducted on the continental shelves.

The systematic geological mapping of the continental shelves, described in the section on research,* is intended to contribute directly to the economic exploitation of the shelf.

* * *

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Public Health Service

FY 1965—$ 30,000†
FY 1966—$130,000†
FY 1967—$167,000

Public Health Service (Shellfish Sanitation Branch) will cooperate with State agencies in making special studies of water quality in shellfish areas (*e.g.*, a long-range ecological study in the vicinity of the Oyster Creek, New Jersey, nuclear power station), and will assist the twenty-two coastal States in planning water quality studies in areas approved for shellfish production under the National Shellfish Sanitation Program. Public Health Service will also cooperate with the Federal Water Pollution Control Administration in estuarine studies undertaken in support of pollution abatement work in shellfish production areas.

*The Geological Survey's Continental Shelf Reconnaissance Program is considered a research effort by the ICO and the Geological Survey.

†Federal Water Pollution Control Administration programs for FY 65 and FY 66 are presented separately from Public Health Service for program comparison purposes. However, water pollution control activities were removed from the Public Health Service December 31, 1965, and placed in this newly established Administration. The Administration's first separate budget was prepared for FY 67.

The National Register of Shellfish Growing Areas will be expanded moderately though pilot efforts with a limited number of State agencies. This register describes the location of shellfish available to commercial exploitation.

Federal Water Pollution Control Administration

FY 1965—$ 650,000*
FY 1966—$ 699,000*
FY 1967—$1,470,000

In FY 1967 the Federal Water Pollution Control Administration will develop comprehensive programs for water pollution control in the Delaware Estuary, Chesapeake Bay, the Hudson Champlain-metropolitan coastal area, along the Central Pacific coastline, the coastal portions of the lower Mississippi, the coastal portion of the Columbia River basin and adjacent Pacific Northwest waters, in the coastal waters of New England, and the coastal portions of Puerto Rico and Florida. These programs include studies on the effects of waste disposal upon water quality in estuaries and coastal areas. Water movements, marine biology, and water quality conditions also are investigated.

Two new technical assistance investigations will be initiated, one in the Charleston Harbor-Cooper River area, the other in the Tampa Bay, Florida area. The Charleston Harbor-Cooper River study will be concluded and an engineering analysis and report prepared in FY 1967. It is a cooperative effort with the Army Corps of Engineers to evaluate the possible effects on water quality that would result from the diversion of a portion of the Cooper River from the harbor to prevent excessive silting (also of concern to United States Navy interests in the harbor). The Tampa Bay project will determine the source and effect of waste discharges on the Bay (with particular attention to Hillsboro Bay), and evaluate hurricane protective barriers proposed by the Corps of Engineers for Hillsboro Bay. This work will provide better water pollution control. The operation will be incorporated into the Florida-Puerto Rico Comprehensive Project in FY 1968.

* * *

*Federal Water Pollution Control Administration programs for FY 65 and FY 66 are presented separately from Public Health Service for program comparison purposes. However, water pollution control activities were removed from the Public Health Service December 31, 1965, and placed in this newly established Administration. The Administration's first separate budget was prepared for FY 67.

DEPARTMENT OF TREASURY

Coast Guard

FY 1965—$ 639,000
FY 1966—$1,073,000
FY 1967—$1,383,000

This funding encompasses the cost of EVERGREEN's operation; the cost of the survey effort which is additional to the primary missions of the supporting ships and aircraft; the operating cost of the Coast Guard Oceanographic Unit which processes, analyzes, and publishes the survey data; and technical and scientific training costs. Over 85 percent of the Coast Guard survey effort will be in support of Project SEAMAP.

The icebreaker, NORTHWIND, will engage in ocean survey work in the Arctic, while EASTWIND and WESTWIND perform survey work in the Antarctic and in Baffin Bay on an opportunity basis, as permitted by their icebreaking mission.

EVERGREEN will conduct time series surveys in the Northwest Atlantic Ocean. Synoptic oceanographic observations will be conducted at the four Coast Guard-manned ocean stations in the North Atlantic and the two in the North Pacific. The Ocean Station Oceanography Program will be expanded with inauguration of the seasonal occupation of standard sections across the Gulf Stream, Labrador Current, and California Current.

The Coast Guard expects to provide ship support for the proposed EASTROPAC survey. In conjunction with the Cooperative Study of the Kuroshio, Coast Guard ships will occupy seasonal sections between Ocean Station VICTOR and the Japanese mainland.

Continental Shelf

Coast Guard offshore light stations and lightships will continue the collection of temperature, salinity, current, tide, and wave data as part of the interagency coastal survey network.

Ships engaged in the Alaskan Patrol will make regular surveys in cooperation with other agencies. Coast Guard aircraft on the Atlantic, Gulf, and Pacific coasts will continue monthly infrared radiation thermometer surveys in cooperation with the Bureau of Sport Fisheries and Wildlife, the Office of Naval Research, and private laboratories.

III. MARITIME DEVELOPMENT

The Ocean Engineering Effort

In transmitting the FY 1966 National Oceanographic Program plan to the Congress, President Johnson stated:

> "We are looking forward to a period where our investment in ocean research may bear fruit in terms of faster and more comfortable transportation, more highly developed exploitation of our marine mineral and fisheries resources, increased pollution control, more accurate prediction of storms and tides that endanger life and property, and the strengthening of our national defense."

The Program identified ocean engineering as an area of special emphasis, and indicated that agency programs contributing to this effort would be included in the FY 1967 program document.

Current emphasis on ocean engineering research and development stems from recognition by scientists and engineers that new techniques must be developed for scientific and industrial exploration and exploitation and for strengthening of our national defense, in and on the sea. Scientists wishing to perform research in the ocean must use an engineering approach to insure successful completion of their projects. For example, repeatable sampling of the ocean bottom is in itself an engineering problem of some magnitude, involving accurate navigation, control over sampling procedures, and reliable recovery techniques.

This year's program has been extrapolated back two fiscal years for purposes of accurate accounting and rational analysis of program growth in ocean engineering. Excluding the reprogramming of FY 1965 Defense and AEC funds for development of the Navy's long-endurance, nuclear-powered vehicle, NR-1, the ocean engineering effort identified by ICO in the FY 1967 Program has nearly doubled since FY 1965. This reflects growing recognition in the Federal government of the important role of ocean technology in achieving the objectives of the National Oceanographic Program. A large proportion of these funds have and will continue to go into industrial development contracts. Techniques and hardware requirements derived from these contracts have substantially increased the undersea technology capabilities of American industry. The present ocean engineering effort of the ICO is directed toward enhancing the Nation's ocean engineering capability in:

1. *Structural and Civil Engineering*—The Ocean Engineering Program of the Army Corps of Engineers (including the Coastal Engineering Research Center) consists mainly of design studies and experiments aimed at improving capabilities in (a) shoreline erosion control, (b) prevention of coastal flooding and destruction from storms and hurricanes, and (c) improvement and maintenance of ship channels and harbors in the coastal area.

2. *Deep Sea Recovery Systems*—Two years ago it became evident that our undersea search and recovery capability had not developed sufficiently to meet new operational demands. An extensive program of systems development for submarine location, escape and rescue, and object recovery, was assigned to the Navy's Special Projects Office based on their past experience in the development of the Fleet Ballistic Missile Weapon System. Engineering techniques derived from this major effort will be of significant value to other projects in the ocean engineering program.

3. *Man in the Sea* (biomedical research and undersea habitation systems)—This effort is closely associated with the Deep Sea Recovery System in that it will provide the capability to send men into depths of up to 1,000 feet with relatively simple life support systems. The ultimate goal of this program is to allow man to work efficiently at high ambient pressures. Since working at depth requires prolonged exposure at sea, a parallel effort is directed to the development of undersea habitation to provide living and storage facilities for divers.

4. *Undersea Research Vehicles*—Many agencies have expressed interest in obtaining URVs for exploration and engineering purposes and several have found it profitable to rent available commercial URVs. Evaluation of existing vehicles will be undertaken by the Navy. The Navy, as part of their FY 1967 Program, will develop and build two vehicles for undersea operations.

5. *Resource Development*—This effort is characterized by the Bureau of Commercial Fisheries

program to develop and improve methods of fish harvesting, and the Bureau of Mines' investigations into sampling and recovery techniques for marine mineral deposits.

6. *Deep Ocean Drilling Technology*—In order to answer many important basic questions about the origin of the ocean basins and the nature of the earth's sediments, crust and mantle, scientists and engineers have developed new methods to drill through the sediment carpet on the ocean floor into the mantle. Among the most exciting of these efforts is Project MOHOLE, sponsored by the National Science Foundation. The most geologically favorable sites for this investigation are in the deep ocean. Technology perfected for this particular program has far reaching implications in terms of the future scientific and economic exploitation of heretofore inaccessible portions of the ocean.

7. *Nuclear Power for Deep Ocean Technology*—Large scale engineering projects in the ocean require continuous power. There is a variety of ways in which power can be generated at sea. The most attractive for long-term projects appears to be nuclear generated electricity. Because of the need in oceanography for stable sources of power, the Atomic Energy Commission has undertaken a development program in nuclear devices capable of producing electricity. These sources range in size from milliwatt to megawatt capability. The availability of nuclear power generators to the oceanographic community will greatly influence the rate at which the marine environment can be exploited for the benefit of man.

8. *Supporting research, test and evaluation of materials*—The construction of vehicles, structures, equipment and power plants for oceanographic use, particularly for long-term exposures to deep depths or on the sea floor, introduces new environmental parameters for structural and functional materials and intimately related design concepts, for which very little environmental data have been available. For example, corrosion and other forms of deterioration due to marine life, in both metallic and non-metallic materials, obviously will be a major consideration. New types of structural materials, such as monolithic glass and fiber-reinforced composites, keyed to new design approaches offer great potential for more efficient construction. Extensive programs have been established by the Navy to acquire the necessary theoretical and experimental background and design data. Results from these investigations will be applicable to both military and civilian pursuits and to American industry involved in oceanography.

The basis of the Federal ocean engineering effort is a balanced attack on problems related to the mastery of the marine environment. Ultimate use of the technology developed through these programs will allow man to use efficiently the presently untapped potential of the world oceans in the national interest. Programs in ocean engineering and technology in support of the mission requirements of the ocean engineering oriented agencies are described in the following paragraphs.

* * *

DEPARTMENT OF DEFENSE

Department of the Army

U.S. Army Corps of Engineers

FY 1965—$ 576,000
FY 1966—$ 696,000
FY 1967—$1,220,000

The Ocean Engineering Program of the Corps of Engineers is directed toward improving engineering techniques of (1) controlling shoreline erosion, (2) preventing coastal flooding and destruction from major storms and hurricanes and (3) improving and maintaining coastal navigation channels and protected harbors for ocean cargo vessels and recreational craft. As in the research program, the major portion of this work is performed by the Coastal Engineering Research Center (CERC), Washington, D.C. in cooperation with other Federal agencies, state governments, and private firms and institutions. This effort supports the Corps' basic mission: civil engineering in the near-shore environment to protect lives and property and to conserve resources held in common by the American people. The entire program contributes to the overall ICO continental shelf program.

Proposed FY 1967 Program

Coastal Works Evaluation

This project entails the collection of data before and after construction of coastal engineering works to determine the adequacy or inadequacy of functional and structural designs. Data are collected on repeated surveys of the structures and adjacent areas (onshore and offshore) to determine the oceanic forces applied and the results of the application of these forces.

Data are procured in cooperation with field offices of the Corps of Engineers (and other public agencies when possible) and compiled at CERC. Data are also compiled from technical literature (both foreign language and English) regarding improvements in coastal engineering in foreign countries.

Functional Design of Coastal Works

The influence of particular shore structures or of improvements on the natural shore processes will be studied in relation to shore behavior. Conformance of applicable design relationships will be evaluated for application to existing design criteria or development of new design relationships. Procurement of data will continue on the construction of shore connected gravity or cantilevered structures, offshore structures, beach and dune restoration and nourishment projects, and on the techniques used to effect the mechanical transfer of littoral drift past a littoral barrier. Reports will be prepared for publication as CERC technical memoranda, bulletins, and miscellaneous papers. Where applicable the findings are incorporated into the technical report "Shore Protection, Planning and Design."

Structural Design of Coastal Works

The purpose of this program is to determine the structural effectiveness of coastal shore improvements projects. Its application is to develop and improve criteria for use in the structural design of coastal works.

Construction Techniques

Construction techniques used in building various types of structures are observed and information collected to define those techniques which will improve construction methods. Information derived from these studies will be disseminated in the form of manuals and motion pictures.

Environmental Data Collection

This project involves regional studies of field conditions; the inventory of sand deposits for use in beach fill operations; the study of the economic life of construction materials; and the collection, compilation, and analysis of ocean wave records. In the regional studies, all readily available data will be compiled on the littoral materials of a region, its geomorphology, littoral forces, and shore line history. The coastline of the U.S., including that of the Great Lakes, has been divided into regions which more or less define littoral compartments; reports will be made on each compartment independently as basic data are accumulated.

Technical Services

Advice will be given as requested to other agencies on problems in the general fields of oceanography, hydrography, hydraulics, instrumentation, and structures. This project also includes technical review of reports (as Navigation, Beach Erosion Control, Design Memoranda, *etc.*) when directed.

* * *

Department of the Navy

Naval Material Support Establishment

Bureau of Yards and Docks

FY 1965—$ 806,000
FY 1966—$1,466,000
FY 1967—$1,365,000

Background

The basic objective of this program is to provide the Navy with a capability for constructing fixed installations in deep ocean areas. The approach will be to obtain the necessary information, techniques, and equipment through an orderly

program of exploratory development. The ultimate goal is to create, train and equip two construction battalions to perform underwater operational and logistic support tasks. Industry will be provided with data on deep ocean construction materials, equipment, and techniques. The Bureau serves the oceanographic community as the lead agency in the development of deep ocean civil engineering and its associated technology.

The program is based on the following assumptions:

All manned structures on the ocean floor will be of the pressure hull type based on submarine design concepts.

All manned structures will have a small positive buoyancy or jettisonable elements to provide for surfacing in an emergency.

Prefabrication will be used to the maximum extent feasible.

Power and communications will be the only underwater utilities required.

Proposed FY 1965 Program

For planning purposes, the Deep Ocean Civil Engineering Program carried out at the Naval Civil Engineering Laboratory at Port Hueneme, California, is divided into seven principal areas of technical interest. Detailed objectives developed for each area are summarized below:

Site Selection and Surveys

This project entails the creation of surveying and mapping systems for underwater construction and the translation of known reference points from bottom-to-surface and surface-to-bottom. Site surveys also include the gathering of information on the particular environmental parameters relative to materials selection, currents and biological conditions. In FY 1967 a comprehensive review of available equipment will be undertaken as a basis for the assembly of surveying systems suitable for construction purposes.

Bottom Soil Properties and Foundations

Testing procedures must be developed for underwater (*in situ*) determination of plate bearing ratios, long-term settlement, shear strengths, and the dynamic bearing capabilities of bottom soils. Laboratory testing procedures for samples recovered will be improved. Suitable engineering test methods are required to provide a technical competence in this new field.

Techniques for predicting the stability of bottom slopes, as related to submarine slides, turbidity current action, and seismic disturbances will also be included in the engineering properties evaluation studies.

The effort in FY 1967 will include further studies and testing of soils in a pressure vessel, *in situ,* and the laboratory, using core samples.

Construction Equipment

The most attractive concept for construction envisions the structure being manufactured elsewhere, towed to the site and lowered. More elaborate facilities would be prefabricated in sections.

This will require systems for handling, placing, lowering and assembling components (up to 150 tons) in a deep ocean environment. Conceptual studies on materials handling units, excavating, and welding are planned for FY 1967. Development programs in these areas will also be initiated as design criteria are established.

Anchors and Moorings

Deep sea anchoring systems of up to 300,000 lbs. hold capacity will be developed. In addition to systems of ultra-high capabilities, precision moorings with low excursion radii will also be studied. FY 1967 plans include further development of embedment anchors and the installation of prototype moorings.

Design and Construction

The Bureau's Civil Engineering Laboratory is continuing a study of the behavior of materials in the deep ocean environment. Compilation of information on the responses of materials will lead to improved design and construction of fixed installations on the ocean bottom. Deep water operations will be simulated in shallow water experiments. Compiled information on the designs, methods and equipment for deep ocean construction will be published for the guidance of engineers.

Power Sources

A comparative analysis of three systems for supplying power to an underwater installation will be undertaken: (1) generation of power on the sea floor; (2) transmission of power from shore installations; and (3) transmission of power from moored surface platforms.

Supporting Systems

The Bureau is developing facilities for testing components in a simulated deep ocean environment. Procurement has been initiated for a 5,500 psi pressure tank, 6 feet in diameter by 16 feet long, to be delivered early in FY 1967. In addition to this equipment further development will be undertaken on a complete deep ocean placement and observation system for conduct of *in situ* tests of all types at suitable deep ocean test sites.

Special Projects Office

(Deep Submergence Systems Project—DSSP)

FY 1965—$33,500,000*
FY 1966—$12,400,000
FY 1967—$32,846,000

Background

The Deep Submergence Systems Project was established by the Secretary of the Navy in June 1964, and placed under the management of the Special Projects Office. In February 1966, the Deep Submergence Project was established as a CNM designated project as a separate entity. Its broad objective is to provide the system capabilities and supporting technology required by the Navy to operate throughout the ocean's volume. The project's major elements are outlined below.

Proposed FY 1967 Program

1. *Submarine Location, Escape, Rescue*

(a) *Location*: The objective is to achieve a capability to locate a distressed submarine and determine the cause and nature of the disablement. Aids to investigation may include a pinger and alerting timer.

(b) *Escape*: A three part program to improve present submarine and undersea vehicle escape capability is planned.

(1) Immersion suits and one-man life rafts to increase the survival possibilities of escaping personnel.
(2) Improved escape training of undersea vehicle personnel.
(3) An experimental 600-foot open-sea free ascent to demonstrate the feasibility of emergency exit from a disabled submarine at deep depths.

(c) *Rescue*: A new rescue system is planned to permit the rescue of surviving submarine personnel under all weather conditions, under ice, and at depths as great as present submarine collapse depths. This system will consist of three units of rescue submersible vehicles, each unit to be comprised of two vehicles. These vehicles will be air transportable to provide rapid response to an undersea disaster anywhere in the world. They will be carried to the scene of operations "piggyback" aboard a nuclear submarine or aboard a specially configured surface support ship. The vehicles will be designed to operate at a maximum depth consistent with technology and cost constraints. Each will have a crew of two operators and one medical technician and will be capable of transferring at least 12 survivors on each trip from the disabled submarine to the mother submarine.

In FY 1967, fabrication and assembly of the rescue prototype vehicle will continue, and work will commence on the first of five operational rescue vehicles. Operator and maintenance crew training will also be started and the feasibility of training personnel to escape from 200-foot depths will be investigated.

2. *Deep Sea Search and Small Object Recovery*

More than 80% of the ocean volume lies below present Navy operating capabilities. A system is needed to permit surveys, investigations, and recovery of small objects, such as ordnance and small parts of ships, from depths to 20,000 feet. A search test vehicle will be designed to evaluate new materials and equipment. In addition, a deep sea test range will be developed to test concepts

*Includes $30,000,000 for NR-1 Development.

and vehicles equipment and systems under controlled and monitored conditions. Intensive research will be conducted on material problems associated with 20,000-foot depth vehicles.

An *in situ* test range being built at San Clemente Island, under the direction of the Naval Ordnance Test Station, will be completed by the end of the fiscal year and will be available for testing DSSP components and systems.

3. *Man-in-the-Sea*

This system's objective is to provide a capability for support of rescue and salvage operations, maintenance of bottom-mounted equipment, exploration and exploitation of the continental shelf, and possible assistance in military operations associated, for example, with mine defense and amphibious assaults. Emphasis will be on the adaptation of man to the deep sea environment at *ambient pressure* for the particular depths of operations. The program will increase the effectiveness of all other DSSP systems. Man-in-the-Sea will involve:

(a) Physiological research and experimentation.

(b) Mobile pressure equipment development needed for decompression.

(c) Surface ship modifications to support diving operations.

(d) Advanced sea habitations to provide underwater living and storage facilities to future aquanauts.

(e) Development of auxiliary items such as improved diver-to-diver and diver-to-surface communications, and improved underwater propulsion devices.

An advanced development objective also exists for extension of Man-in-the-Sea technology, first to depths below the continental shelf and ultimately down to the physiological limits of man.

Initially, one advanced sea habitation and its auxiliary equipment will be established on the continental shelf. Divers will then be able to operate from this shelter for a month or more without coming to the surface. SEALAB I and II, Man-in-the-Sea experiments conducted off Bermuda in 1964 and La Jolla, California, in 1965 respectively demonstrated that one diver, living at 200 feet without daily decompression, can perform as much work in six hours as 35 divers operating from the surface. During the latest experiment—SEALAB II—two major programs were conducted:

(a) A human performance program designed to gain an overall estimate of man's undersea working capabilities.

(b) An oceanographic program, consisting of various physical and biological activities which can only be accomplished on the sea floor.

In FY 1967, refurbishment and implementation of the SEALAB equipment will be started and the operational site selected and prepared. A SEALAB III experiment at 400 feet will be conducted to obtain necessary data for deeper depth operations.

A biomedical, physiological, and hydrobiological research program will also be conducted to support the development program.

4. *Large Object Salvage*

This system's objective is to provide the capability to recover large objects—including sunken ships—of a deadweight lift of 1,000-tons from continental shelf depths, 600 to 850 feet. To accomplish this mission, external lift will be supplied by collapsible pontoons, with a combined buoyancy of up to 1,000 tons. Underwater work will be accomplished by divers equipped with appropriate tools and devices, possibly including manned vehicles. The medical and physiological research and development required for safely conducting deep diving work will be provided by the Man-in-the-Sea program. In addition, feasibility studies and prototype development will be conducted to resolve the problems associated with salvage operations at submarine collapse depths.

Buoyancy materials will be developed to lighten objects, and for exerting an external lift. Investigation, object preparation, and rigging will be accomplished using divers or manned submersibles developed under the Man-in-the-Sea rescue and search programs. When achieved, this system objective—deep ocean salvage—will extend man's work capabilities far below the 280 feet presently attainable by standard diving methods.

A program will be conducted in FY 1967 to develop and then procure underwater work equipment such as drills, hull attachment devices, power sources, cutting devices, and collapsible pontoons. Additionally, detailed design for the

construction of a salvage unit composed of three surface ships, an underwater diver's hut, and a submersible decompression chamber will be made.

Research on gas generation under ambient sea pressures, displacement and dewatering materials, and pontoons systems controllability is planned. Problems associated with adapting deep submergence vehicles for salvage use will also be investigated.

5. *NR-1 Nuclear Ocean Engineering and Research Vehicle*

The capabilities of manned underwater research vehicles developed to date are limited by the short endurance of propulsion and auxiliary power. Development of a nuclear propulsion plant will give a research vehicle the freedom to move over the ocean bottom for weeks at a time. The vehicle's endurance will not be determined by the powerplant but rather by the crew and food and water supplies.

The Department of the Navy and the Atomic Energy Commission are jointly developing a nuclear powered deep submergence research and ocean engineering vehicle, designated "NR-1." The capability of this manned prototype vehicle will be far greater than any other developed or planned to date because of the vastly increased endurance made possible by nuclear power.

The Navy's DSP has overall responsibility for the NR-1's development. The Bureau of Ships is responsible for vehicle design, development, and construction. The Atomic Energy Commission's Division of Naval Reactors is responsible for the design, development, construction, and test of the nuclear propulsion plant. Design and development of the reactor has been assigned to the Atomic Energy Commission's Knolls Atomic Power Laboratory, Schenectady, New York. Design and construction of the vehicle will be done at General Dynamics Corporation's Electric Boat Division, Groton, Connecticut.

A pressurized water reactor of low power will be used to provide vehicle propulsion and auxiliary power. The reactor will be located in the vehicle so as to minimize shield weight. A cylindrical pressure hull fabricated of HY-80 steel will be used for the vehicle. Viewing ports and lights for viewing outside the vehicle, cameras for taking pictures of what is seen, and apparatus to pick up items from the bottom of the ocean will be provided.

Development of the NR-1 was announced by the President on April 18, 1965. The area of the ocean floor made accessible by this vehicle includes all of the world's continental shelves. Because of its long submerged endurance, this vehicle will be able to perform tasks heretofore only imagined. It will be able to perform detailed studies and mapping of the ocean bottom for commercial and scientific purposes. It will be able to obtain information leading toward greater exploitation and control of the oceans' resources, including marine life and minerals. It will be capable of locating and retrieving objects of commercial, scientific, and military value from the ocean. This vehicle will be made available for use by agencies other than the Navy.

The cost to the Navy is estimated to be $30 million, all of which is derived from FY 1965 funds. The Atomic Energy Commission is programming $3,000,000 for FY 1967 for development and procurement of the vehicle's reactor system. (See AEC, p. 65.)

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Naval Oceanographic Office

FY 1966—$ 385,000
FY 1967—$1,500,000

NAVOCEANO's engineering effort in FY 1967 is being directed in two main channels: The first is the establishment of specific Navy project requirements for a deep diving research vehicle, including the sensors to be installed, and necessary support equipment. The second is the acquisition of operating experience in these vessels. These must necessarily go forward concurrently, since effective future use will depend upon employment of the URV as a tool integrated into the total package of oceanographic hardware and ships.

To accomplish these aims, URVs will be leased to gain operating experience and explore techniques for the use of these craft. Based on this experience, firm requirements will be developed and designs completed for two shallow depth vehicles in FY 1967. Preliminary consideration will be given to design and requirements for a very deep diving vehicle during the same time

period. Development of specifications, sensors, and ancillary equipment will be carried out concurrently under the supervision of the Deep Submergence Program.

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DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY 1966—$270,000
FY 1967—$270,000

The purpose of this program is to develop advanced methods of economically harvesting marine resources. This effort will involve development work in upgrading and improving contemporary methods and technical assistance in applying new harvesting procedures. Conceptual engineering studies will be conducted in theoretical areas to consider means of applying physical and chemical methods to control animal response. New systems development proposals will be evaluated and contracts will be made with agencies of proven experience in this field.

Bureau of Mines

FY 1965—$134,000
FY 1965—$209,000
FY 1967—$210,000

The Bureau of Mines is authorized to determine the industrial value of marine minerals and to develop techniques for their sampling and recovery. To this end, the Marine Mineral Technology Center has been established at the Tiburon Naval Net Depot, near San Francisco.

Two ships have been acquired and improvement of the facility initiated. Emphasis in FY 1967 will be on the development of improved mineral sampling devices, and on the acquisition and analysis of marine mineral deposits with respect to their environmental and physical characteristics. These data are needed to determine realistic marine mining system requirements.

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NATIONAL SCIENCE FOUNDATION

FY 1965—$24,700,000
FY 1966—$17,900,000
FY 1967—$19,700,000

Background

The Mohole Project represents man's first attempt to explore the earth's deep crust and mantle beneath the sea. It will open this vast and little known region of the earth to science and thus will provide important facts about the earth as a planet.

Much has been inferred about the nature of the earth's crust and the underlying mantle. Such indirect methods, as seismic reflection and refraction, and scientific theories developed through such methods remain unproved and must be tested through actual experimentation and direct observation. By drilling through the crust and into the earth's mantle as far as possible scientists hope to:

1. Obtain a better age determination for the earth.
2. Determine the age and origin of the ocean basins and their waters.
3. Better understand how the earth-moon system came into being.
4. Broaden our understanding of the distribution of the chemical elements in the earth, which in turn bears on the origin of the sun and perhaps the stars.
5. Advance our understanding of the origin of continents and the extent of continental drift.
6. Improve our knowledge of the mantle's composition and the origin of magnetic and gravity anomalies that have been discovered beneath the sea.
7. Better understand the origin of life and the carbon cycle with which it is closely connected.

The Mohole Project is considered to be of very great importance by geophysicists, geochemists, geologists and other earth scientists. It has been endorsed by the National Academy of Sciences and by many other national scientific bodies.

The Project has also created great interest internationally. As recently as September 3, 1965, at Ottawa, Canada, an international symposium

sponsored by the Upper Mantel Committee of the International Union of Geodesy and Geophysics (IUGG), a branch of the International Council of Scientific Unions (ICSU), adopted a resolution which said in part "The Mohole Project is most fundamental to advances in knowledge in a wide range of earth sciences and the early initiation of drilling is strongly recommended in places where the Mohorovicic Discontinuity is well established by geophysical measurements..." The Upper Mantle Committee includes representatives of many nations of which Canada, the U.S.S.R., South Africa, and the United States were represented on the Subcommittee in charge of proceedings for the symposium.

In addition to its purely scientific contributions, the Project will contribute technological advances of interest to other fields; indeed it has already done so. The Department of the Navy and NASA have both maintained an active interest in the type of large stable platform that has been designed. The Navy is interested in conducting many kinds of heavy work at sea, including recovery operations, while NASA may need a marine-based satellite tracking station that might incorporate many features of the platform design. A stable platform is also of interest for many types of oceanographic and atmospheric research. It can also make an important contribution to the oil industry as will a modified drill that has been developed for the Mohole Project.

The project is significant from an engineering standpoint because of the unique drilling capability which must be developed. Not only will it require drilling to greater depths than ever before, but the work has to be carried out in deep ocean areas in the hazardous and erratic marine environment. The drilling system is designed to operate from a large stable drilling platform which is self propelled and dynamically positioned. The six-column platform with twin lower hulls, designed jointly by Brown & Root, Inc., the prime contractor on the project, and Gibbs & Cox, Inc., a leading naval architectural firm, will be the largest offshore drilling platform yet built. It is designed to stay on station and drill under such adverse conditions as 30-knot winds, fully developed seas (28-30 foot waves), and 3-knot surface currents.

The positioning system has been developed and is being fabricated to keep the platform on station under conditions described above and within a 500-foot radius circle. Position is maintained automatically but the system will permit manual control of the platform as required.

The drilling system is designed around the conventional rotary drilling methods, with most components requiring upgrading or special design to accomplish the task. A special down-hole turbodrill has been developed, however, which will drill faster than rotary drills and permit continuous coring. It has performed exceptionally well in tests thus far conducted. A retractable diamond bit has been designed which will permit bit changes without pulling the drill string. The drawworks is the largest ever built, and the automatic pipe handling equipment is a first for industry as well.

A sonar device for hole reentry is being developed and underwater television is planned as a back-up system. An underwater vehicle may eventually be required for inspection and repair work. Several devices for down-hole scientific measurements have been prepared and others are in the course of development. The logging winches and controls are under construction and the longest logging cable (40,000 ft) yet required will be procured for use in the holes drilled.

The state of the deep drilling art will be extended by the engineering developments being brought about by the project. While it is a secondary consideration, the significance of this project to the drilling and petroleum industries will be considerable.

Proposed FY 1967 Program

Initial funding for the drilling platform occurred in the middle of FY 1966. The project consists of two major phases: (1) Developing, designing and constructing the necessary capital equipment, and (2) an operational phase which will be continued for many years—perhaps two or three decades. As presently estimated, phase (1) will continue through FY 1967 into FY 1968. Phase (2) will be initiated by drilling several holes to intermediate depths, over a period of perhaps a year, before going to the Maui site (about 120

miles northeast of Honolulu) to attempt to penetrate the mantle proper. The subsequent program will depend upon scientific findings during these first phases.

* * *

ATOMIC ENERGY COMMISSION

FY 1965—$2,237,000
FY 1966—$7,325,000
FY 1967—$8,840,000

The objective of the Atomic Energy Commission's oceanographic nuclear power program is the development of isotopic and reactor power sources to meet the power needs of the National Oceanographic Program, as well as the needs of low power terrestrial applications.

Each application carries an almost unique set of requirements. Since it is clearly not economical to develop a power supply for every individual application, the following discrete power level ranges have been chosen as representing areas of greatest potential applicability at this time.

a. Isotopic power generators in the following electrical power ranges:

(1) 100 to 600 milliwatts

(2) 10 to 200 watts (advanced development work underway)

(3) 1 to 5 kilowatts

b. Nuclear reactor power sources:

(1) 100 KWe* to 2 MWe* for auxiliary power and/or vehicle propulsion

(2) 2 MWe and above primarily for vehicle propulsion

The exact power level interface between isotopic generators and reactors is difficult to define and will be heavily dependent on the cost and availability of the desired isotope. On the basis of current isotopic production rates, foreseeable power requirements, present unit costs ($/curie), and the best projected production rates and costs after the large scale fission product recovery plant becomes available in 1968, it is planned to develop isotopic power generators up to power levels of approximately 5 KWe in the next five years. Power levels for isotopic systems in succeeding years will be determined from studies starting in FY 1967. Reactor systems can be designed for a wide range in power level; therefore, there will be a range where both radioisotope and reactors must be considered. The choice between them will be made on the basis of both the requirements for the applications and the economics involved. Thus, while the direction of the current isotopic program is to develop advanced units in a power range of milliwatts to 5 kilowatts, the reactor program will concentrate on the development of auxiliary power and propulsion systems in the kilowatt to megawatt range.

The initial efforts for the higher powered (1-5 KWe) isotopic units and the nuclear reactor power sources (above 100 KWe) will be directed toward the development of technology that would make possible the delivery of power systems within wide envelopes of operating parameters and design characteristics. The plan is to develop this technology by investigating those areas of isotopic heat sources, nuclear reactors, and power conversion equipment with design uncertainties. This approach will emphasize the development of the materials and components that will be required for specific systems to meet precise specifications.

It is believed necessary to do some integrated component testing prior to development of a definite system to gain experience and data on overall plant engineering and component interaction. This program, therefore, will include the operation of a proof-of-principle reactor experiment or a prototype plant to demonstrate that a practical oceanographic power system can be built based on the technology developed in this and other programs.

The design, development, and testing work in support of this program will be performed by industrial contractors, with support as necessary from AEC laboratories and selected agencies. The testing phase will include performance and operational checks conducted under conditions which will simulate as closely as practical those experienced in actual operation. An environmental test facility will be constructed and operated as part of this program to evaluate and demonstrate the adequacy of all designs.

Proposed FY 1967 Program

1. Isotopic Power Sources—$4,800,000

Isotopic units have been under development for oceanographic, terrestrial, and space applications

*KWe—electrical kilowatts; MWe—electrical megawatts.

since FY 1961. The resulting technology from the first generation units has provided a base to guide the current development of SNAP-21 for undersea applications and SNAP-23 for marine surface and terrestrial applications.

Under the SNAP-21 program, a 10 watt system, is in the final stages of development and will undergo performance testing in FY 1966. Demonstration units are to be fabricated and delivered in FY 1967.

Higher power versions of SNAP-21 (20 and 60 watts) will enter the design phase in FY 1966. This development program will draw upon and extend the technology developed for the lower power unit. The detail design will be completed and component development and engineering tests of critical systems will be conducted in FY 1967. Fabrication of demonstration units of each power level will be initiated in FY 1967, with delivery in FY 1968.

The SNAP- 3 program emphasizes generator economics since it is designed for marine surface applications where it must compete with more conventional power sources. A 60-watt version is being developed and operational testing will begin in FY 1967. Follow-on units in the 25, 100, and 200-watt power range will be developed during FY 1966 with prototype units scheduled for completion in FY 1968.

The development of a very low power (milliwatt range) system will be initiated in FY 1966. Upon completion of detail design, component development and engineering tests will be started in late FY 1966.

A high power (kilowatt range) program will be established in FY 1967. The initial phase of the program will consist of studies to define the key feasibility areas and technology requirements. Among the areas which are expected to be investigated starting in FY 1968 are alternate fuels, fuel forms, containment, power conversion, and waste heat dissipation. Component and system development will be initiated as technological progress permits.

Each development program will provide valuable experience and technology that will guide future efforts. The design and development of additional units or advanced concpets will be initiated as indicated from applications requirements, technological advances, and changes in isotopic cost or availability.

2. Low Power Reactor Systems—$1,040,000

This program provides for the development of technology for low power nuclear reactor systems, initially covering the 100 KWe to 2 MWe range which may be applicable to a variety of uses such as oceanographic power plants and terrestrial power plants, both attended and unattended.

The program was initiated in FY 1966. Based upon the reactor technology developed to date, this program will develop additional technology required for oceanographic and terrestrial systems and will take advantage of applicable advancements achieved within the Space Electric Power Program, Naval Reactor NR-1 Propulsion Reactor Development program, and other related Reactor Development and Technology (RD&T) programs.

Parametric studies were initiated in FY 1966 to define the design features of reactor power plants in oceanographic and terrestrial applications and determine the additional technology required. The features which will be investigated include economic trade-offs, power plant characteristics, size and weight requirements, and special design features required by the terrestrial, marine surface and deepsea environment. The technology areas which are expected to be investigated beginning in FY 1967 include primary systems analysis, key component features, fuel element capability, fuel-cladding-coolant material compatibility, and methods of reactor and plant control.

To demonstrate that component and system technology can be satisfactorily integrated, a proof-of-principle reactor experiment or a prototype plant is planned for operation in the early 1970's. The timing of the reactor experiment is dependent upon the development of the technology and the status of the candidate applications.

3. Naval Reactors Deep Submergence Vehicle Power Plant Development (NR-1)—$3,000,000

The NR-1 is a nuclear-powered, deep-submergence research vehicle being developed jointly by the U.S. Navy and the Atomic Energy Commission. Overall responsibility for the project has been assigned to the Director, Special Projects. The Bureau of Ships is responsible for the vehicle and the Naval Reactors Division of the AEC is

responsible for the entire propulsion plant. (See page 61 for more detailed project description).

Primary emphasis is being placed upon the development of a small nuclear reactor of the pressurized water type which will enable this and future similar vehicles to have endurance limited only by the personnel and supplies.

The AEC portion of this development effort is estimated to cost $7.5 million over a three-year period beginning in FY 1965.

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PART THREE

Support of the Oceanographic Effort

I. Tools for Oceanography
II. Oceanographic Services - NODC
III. Manpower and Training

I. OCEANOGRAPHIC TOOLS

A. Ship Design and Construction

For FY 1967, the Interagency Committee on Oceanography is recommending the construction of two new ships, and the funding of two design studies. The total proposed funding of $16,189,000 represents an increase of $3,699,000 over FY 1966. Table E shows agency budgets for ship construction over the past seven fiscal years.

The appendix lists all U.S. research and survey ships supporting the National Oceanographic Program including those assigned to private institutions and universities.

* * *

DEPARTMENT OF DEFENSE

Department of the Navy

FY 1965—$ 9,000,000
FY 1966—$11,100,000
FY 1967—$13,800,000

The Navy now has 22 survey and research ships operational or on the way, exclusive of the five AGORs provided to private laboratories.

Funds are requested for the construction of a large AGOR-type research vessel. This new design, in the 3,000 to 4,000-ton displacement range, will be assigned to a private institution to support ASW oceanographic research. The design will reflect operational experience with the earlier AGORs, and feature improved sea-keeping qualities, greater endurance, and an expanded scientific capability.

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DEPARTMENT OF COMMERCE

Environmental Science Services Administration

Coast and Geodetic Survey

FY 1965—$9,000,000
FY 1966—$0
FY 1967—$1,689,000

Funds are needed to design, construct, and outfit a replacement for MARMER, a coastal current survey vessel long operated by Coast and Geodetic Survey to obtain comprehensive and accurate current predictions for commercial ports and coastal waterways. MARMER was originally constructed by the U.S. Public Health

Table E
Funds for Ship Construction
(in thousands of dollars)

	FY 60	FY 61	FY 62	FY 63	FY 64	FY 65	FY 66	FY 67
Navy	8,400	4,200	13,600	18,200	8,200	9,000	11,100	13,800
Coast and Geodetic Survey	2,033	4,700	14,185	14,400	13,000	9,000	—	1,689
Bureau of Commercial Fisheries	100	2,005	3,225	2,650	3,107	1,700	690	—
Bureau of Sport Fisheries and Wildlife	—	—	—	—	80	—	—	—
National Science Foundation	3,000	3,093	3,000	2,000	1,104	1,000	700	200
Coast Guard*	—	—	—	—	—	—	—	500
Total	13,533	13,998	34,010	37,250	25,491	20,700	12,490	16,189

*Excludes ocean station vessels.

Service in 1932 as a harbor quarantine cutter. The hull of the ship is constructed of wrought iron. In May 1957 she was transferred to the Coast and Geodetic Survey and converted to a current survey vessel in 1958. An inspection in 1964 by the Maritime Administration found that while the vessel apparently had been well maintained, her advanced age and deterioration has made the vessel unsuitable for ocean service without the expenditure of considerable money to meet Coast Guard safety requirements. Moreover, MARMER can no longer properly accomplish the full objectives of coastal current surveys; requests for additional tidal current predictions have accumulated to a point where other hydrographic survey vessels have had to be diverted from their basic assignments at the risk of setting back the Coast and Geodetic Survey's long-range charting program. Since this vital service to the mariner must be continued in the most efficient and economical manner, MARMER will be replaced by a properly equipped and designed vessel. Design and construction of the MARMER replacement will, therefore, begin in FY 1967.

* * *

NATIONAL SCIENCE FOUNDATION

FY 1965 – $1,000,000
FY 1966 – $ 700,000
FY 1967 – $ 200,000

The National Science Foundation is responsive to scientific proposals received; its program, therefore, is not as firm as those of other agencies. Included in the FY 1967 program of the Foundation is $200,000 to fund a design study of a barge to be used as a platform for study of the Arctic Ocean. The barge will be equipped with laboratory facilities and quarters for scientific personnel. It will be set adrift in the ice and will move gradually through the Arctic Ocean in much the same manner as the ice islands currently used for research. When constructed, this platform will greatly expand the capabilities of U.S. scientists in the Arctic.

* * *

DEPARTMENT OF TREASURY

Coast Guard

FY 1965 – $0
FY 1966 – $0
FY 1967 – $500,000

The Coast Guard has 37 ships with oceanographic capability, many of which were equipped over the last few years. None were constructed specifically as oceanographic ships but rather were equipped as ocean station vessels, buoy tenders, and icebreakers which perform oceanographic work in conjunction with their assigned missions. An additional nine ships will be so equipped for oceanographic observations by the end of FY 1969, completing the conversion program.

In FY 1967, the Coast Guard will contract for design and detailed plans of an oceanographic ship to replace EVERGREEN, a World War II-built buoy tender. The replacement ship will be designed especially for service in the northwest Atlantic. It will be ice-strengthened and completely equipped for oceanographic research in sub-polar regions. The ship will be able to handle buoys and will feature high speed data processing equipment.

B. Oceanographic Instrumentation

FY 1965 – $10,329,000
FY 1966 – $ 9,436,000
FY 1967 – $ 8,437,000

Background

Scientific exploration of the ocean is dependent on the accuracy, precision, and reliability of oceanographic instrumentation. As scientific, engineering, resource development and military requirements grow, the demand on industry to produce new, faster, and more reliable instruments increases. The ICO encourages agencies to cooperate in the development of and procurement of instruments. This cooperative effort is expected to reduce the overall cost of data acquisition.

The ICO is advancing the field of oceanographic instrumentation by increasing emphasis on performance rather than purchase description. This approach is being developed to enable industry to exercise its ingenuity, resourcefulness, and

knowledge more effectively in meeting the needs of the oceanographic community. Although the problem of quality control still remains a major factor in the rejection of oceanographic instruments, industry is improving its reliability engineering.

The FY 1967 program reflects a new approach to the solution of instrument problems: the development of instruments from a systems standpoint. Examples of this are; the engineering approach used by ONR in the development of their large long-range telemetering buoy, the emphasis placed on the uniformity of data output of the expendable bathythermograph, the reliability engineering specifications for a fishnet bathykymograph, and the multi-agency appraoch to prepare government-wide performance requirements for a deep sea thermograph.

The new, more dependable generation of instruments will provide oceanographic survey and research projects with reliable and efficient replacements for the conventional instruments now in use. Emphasis on data format has resulted in new electronic systems with digital outputs. These systems will be put into field use during FY 1967. As newer devices of this type are phased into use, more efficient data handling, ease of operation, and reduced maintenance will lower the cost of data collection.

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DEPARTMENT OF DEFENSE

Department of the Navy

Office of Naval Research

FY 1965—$940,000
FY 1966—$940,000
FY 1967—$940,000

The Office of Naval Research's five year program to develop a reliable long range telemetering buoy should be completed during FY 1967. In the final system a number of buoys anchored in the deep ocean will report oceanographic and meteorological data on command to a mobile shore station by high frequency radio links over distances up to 2,500 miles.

This carefully controlled engineering and instrumentation project has resulted in an unusually stable and versatile buoy with electrical and mechanical subsystems of great durability and high accuracy. The discus shaped buoy hull is 40 feet in diameter and seven feet thick and supports a 40-foot combination exhaust snorkel and discone antenna mast. A nickel-cadmium battery bank, capable of supplying 200 watts of continuous power, is charged by two propane fueled, one-kilowatt generators. Telemetry is provided on one of three frequencies selected to ensure good data transmission quality at all times.

Up to 100 sensors can be interrogated and their information stored in two memories within the buoy. One memory will store an entire year's data while the second telemeters information accumulated over the past 24 hours on demand from the shore facilities. This will occur every six hours. Data will be transmitted as a pulse coded modulated signal on a frequency-modulated single side band carrier of 100 watts average power.

During the past year the prototype hull has been anchored in the axis of the Florida Current off Hollywood Beach, Florida. Considerable engineering information was obtained on the response of the buoy, its mooring line forces, dynamic loading characteristics, and the performance of the power supply, navigational warning hardware, and telemetry system. In September of 1965, the buoy remained anchored and in operation during the passage of Hurricane Betsy. Interrogation during this period indicated winds in excess of 100 knots and waves as high as 50 feet. The survival of the buoy and its mooring system under these adverse conditions is a tribute to the carefully engineered design characteristics of the overall system.

Parallel programs, necessary to the development of the overall buoy system have also been supported over the past year. A handbook summarizing the forces and motion of the mooring line will be issued shortly. Investigations into the anti-fouling properties of organotin compounds show promise of affording protection to sensors for periods as long as one year. The testing program on mooring line materials will continue in order to determine optimum characteristics for deep sea use. Evaluation of the prototype sensor package, designed for one year unattended operation, will continue as an important part of the overall instrumentation program.

In FY 1967 additional buoys and allied equipment will be purchased for use in an integrated network for physical oceanographic research.

Naval Oceanographic Office

FY 1965—$5,689,000
FY 1966—$4,513,000
FY 1967—$4,683,000

The Navy's Oceanographic Instrumentation Center will continue to support the Oceanographic Office, other Navy activities, and the general oceanographic community, in the development and procurement of improved oceanographic research and survey instruments and of related hardware. Testing and evaluation of oceanographic instruments will continue with prototypes being procured for laboratory and field evaluation. Funds will be used for the development of standards, evaluation, and support of in-house personnel to carry out test and evaluation programs. The two year old evaluation program and Instrument Fact Sheet distribution will be expanded.

The prototype Shipboard Survey System installed on the USNS SILAS BENT in FY 1966 will be throughly evaluated and adjusted for use at sea. Integration of the ship's position input to the system computer will be a major consideration during FY 1967.

The "ships-of-opportunity" developmental program will be continued to equip commercial and military vessels with a self-contained, portable oceanographic instrument package. These packages can be operated by crew members without interference with the ship's assigned mission. Data from the program will be recorded in a formate suitable for retrieval, processing, and storage by the National Oceanographic Data Center. There, it will be available to all interested organizations.

A "fail-safe" program has been initiated to develop instrument recovery capability to minimize the loss of expensive towed instruments. If an instrument is submerged significantly below its operating depth a recovery derrick will cause the instrument housing to become positively buoyant thus returning it to the surface for recovery. Follow-on planning provides for the development of a family of "fail-safe" devices for both ship-deployed and bouy-mounted systems. Prototype development, in cooperation with the Naval Weapons Laboratory, Dalgren, Virginia, is scheduled for completion early in FY 1967.

A sub-surface buoy array will be completed and instrumented to measure and telemeter data on the environmental forces affecting the buoy, its resulting motion, and the strain on the mooring cable. Several existing buoy systems will be similarly instrumented to provide comparable data to aid prediction, performance, and improvement of design criteria.

Research and development activity during the coming year will include the development of an airborne wave height meter, a study of the sonar equipment which provides ocean floor profiles, and studies of the propagation and attenuation of sound and light in sea water. Results will form a basis for the development of an expendable telemetering instrument to relay information on temperature, depth, sound, velocity, and ocean currents to fast moving ships.

The Center's capability to develop standards and to test and evaluate equipment will be strengthened by adding to the testing facilities of the environmental laboratory. A low speed, flow calibration tank using sea or fresh water will provide current velocities of from 0.01 to 5.0 knots to calibrate current meters and to aid the development of improved current measurement methods. The salinity-temperature calibration system will consist of a saline water tank equipped to heat, cool, and agitate the water to insure precise temperature control; provision will be made for the long term storage of water at five discrete salinities. A lowerable platform will be installed in the oceanographic test tank to facilitate testing instruments down to a depth of 60 feet. A dissolved oxygen test system, capable of accurately measuring the oxygen content in sea water, will be used in evaluation of shipboard and *in situ* devices.

Advanced Research Projects Agency

FY 1965—$910,000
FY 1966—$500,000
FY 1967—$400,000

By means of contracts through other government agencies, the Advanced Research Projects

Agency plans to continue its exploratory development work in ocean-bottom seismology. It is expected that the main effort will be directed toward testing of the shore monitored, cable connected, ocean-bottom seismograph station concept. However, some attention will be given to the redesign of existing prototype untethered devices to improve the reliability of instrument packages and to enhance successful recovery of untethered ocean-bottom seismographic systems.

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DEPARTMENT OF COMMERCE

Environmental Science Services Administration

Coast and Geodetic Survey

FY 1965—$ 600,000
FY 1966—$1,062,000
FY 1967—$ 706,000

The Coast and Geodetic Survey has increased the automation in its instrument and data handling systems by the development of the new ODESSA buoy system for ocean survey programs. A multiple chain of sensors measures conductivity, temperature, depth, current speed, and current direction. Digitized data is recorded in the buoy and is telemetered to either a ship or shore sation. These monitoring stations are capable of simultaneously recording the transmissions of several buoys.

The bottom-mounted deep sea tide gauge system originally tested at 1,000 feet, will be installed in 5,000-foot depths in FY 1967.

The new tidal current meter system, developed for use with the ODESSA buoy system, makes it possible to increase the number of stations at which current data can be measured from a single ship. The ODESSA data format is designed for automatic processing.

The underwater stable platform is a buoy held thirty meters below the sea surface by a three-wire moor to minimize rotation and vertical and horizontal motions. It has been successfully placed in water 2,000 feet deep, and additional installations are planned for FY 1967.

The automatic hydrographic survey system has been designed to automate the collection and storage of hydrographic, oceanographic, geophysical, and meteorological data on deep-ocean survey vessels. The system includes real time computer control of x-y plotters. In FY 1967 this system will be installed as an integral part of C&GS survey vessels.

A satellite navigation system has been installed on a survey vessel and from operational evaluations to date the system looks promising. An additional unit and further system evaluation is planned for FY 1967.

Institute for Oceanography (Sea Air Interaction Laboratory)

FY 1965—Budgeted under Research
FY 1966—Budgeted under Research
FY 1967—$44,000

SAIL is working to improve methods of data acquisition at the sea air interface—the gradient level of the atmosphere and the mixed layer of the ocean. Work is in progress on such indirect sensing techniques as microwave and visible light refraction and radiation.

The planetary boundary layer sensor system measures temperature, humidity, wind velocity and direction, and radiation from the sea surface to the gradient level (sea level to 3,000 ft. above). The infrared sensors for measuring sea surface temperature will be used aboard an ESSA research aircraft.

Engineering development will be carried out on the ship board data acquisition and processing systems for measuring variables of surface environment. A new microwave sensor will provide an indirect technique for the measurement of humidity.

DEPARTMENT OF TREASURY

Coast Guard

FY 1965—$1,218,000
FY 1966—$ 871,000
FY 1967—$ 301,000

In FY 1966 a coastal monitoring program will commence at the Buzzards Bay entrance light

station with the installation of an automatic oceanographic sensing and recording system. This system will collect routine measurements of temperature, salinity, and currents of both surface and sub-surface waters, and also of pressure on the bottom. With this system, it will be possible to conduct seasonal studies of oceanographic parameters with long term sequential information. A portion of the FY 1967 instrumentation budget ($175,000) will be spent for two *in situ* sensor systems for off-shore light towers.

Maintenance of the equipment procured in 1965 and 1966 expanded instrumentation programs, including calibration and testing services, will cost an additional $126,000.

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DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY 1965—$800,000
FY 1966—$800,000
FY 1967—$900,000

In the past year the Bureau increased its capability to locate and record the characteristics of fish populations by the procurement of two new research sonars. A simrad research sonar installed on the DAVID STARR JORDAN, is the first instrument of its kind to be used by this country in the Pacific Ocean. The straza fisheries research sonar, a unique, continuous transmission frequency modulated system, is to be installed on the TOWNSEND CROMWELL. Information obtained on the magnetic tapes of these two powerful systems will provide a new "window" to observe the behavior and distribution of tuna, sardines, and anchovy at medium depths. The systems are capable of tracking individual fish as well as schools.

To improve instrument quality, a new type of program management contract was let with NAVOCEANO for an industry developed fishnet bathykymograph. Emphasis on reliability engineering, availability time, longevity, data handling, and simplicity of application will provide the most economical means for data collection. The apparatus will measure the total commercial fishing effort for the International Commission of Northwest Atlantic Fisheries.

Scientists and engineers from the Bureau, a NASCO Panel on Biological Methods, and industry are cooperating to determine the effectiveness of present plankton sampling techniques and to determine engineering requirements for a new generation of nets. Hydrodynamic characteristics of 14 standard and experimental devices were measured at various velocities in the David Taylor Model Basin. Related observations on the effects of clogging and net avoidance are being made with instrumented samplers from the submerged, windowed laboratories of the DAVID STARR JORDAN, the TOWNSEND CROMWELL, and from leased submersibles.

Systems are being developed to provide a three-dimensional temperature pattern to compare with the distribution of commercial fishes. Commercially available expendable bathythermographs and recently developed near-surface reference temperature devices are being evaluated on merchant ships of opportunity and fisheries research vessels to provide information on operational characteristics. Navy's Fleet Numerical Weather Facility is participating in the evaluation and is receiving data by radio and processing it for further distribution. Results will establish criteria for human factors engineering and data handling procedures. Work on two BCF buoy programs will be continued. Walden-type drift buoys will be outfitted with sensing, positioning, and telemetering systems for use in the northeastern Pacific, and instrumented anchors of standard Coast Guard buoys will be used in the observation of bottom temperatures off Cape Cod.

The Bureau will continue its development of the above instruments and systems ($385,000) for its research and survey programs and will assist in development projects funded elsewhere in government and industry to assure the adequacy of end-products for Bureau-wide use. Further development will continue in long-range sonar for fish detection, dual channel recorders to provide information on the depths and temperatures of commercial catches, fish pumps with attracting lights, and a fish scale reader for age composition data. Close cooperation and liaison with pertinent groups in other agencies will continue.

Services to laboratories and bases ($75,000) will consist of tests, maintenance, calibration, and coordination of information exchange among instrument users in the Bureau and elsewhere. Approximately 49% or $440,000 will be spent for direct procurement of instruments.

Bureau of Sport Fisheries and Wildlife

FY 1965—Reported in Research Budget
FY 1966—Reported in Research Budget
FY 1967—$25,000

BSF&W has procured nets, bathythermographs, high speed plankton samplers, infrared thermometers and sonar equipment for research into the environments which maintain sport fisheries. During the last fiscal year the Bureau purchased an atomic spectrophotometer and supporting equipment for the determination of pesticides in the marine environment. Additional airborne infrared thermometers, plankton samplers, bathythermographs and analytical equipment will be purchased for use in investigation of the factors affecting the location and natural history of fishes.

Geological Survey

FY 1965—$127,000
FY 1965—$138,000
FY 1967—$138,000

The Geological Survey will continue to develop and procure instruments for studying geologic resources on and beneath the ocean floor, and for determining the effects of fresh water and sediment discharge from the land on the marine environment. In its West Coast program, emphasis will be placed on purchase of precision navigation equipment and geophysical instruments for installation on vessels. They will be used in logging drill holes in the ocean floor. Development of improved analytic devices for use in studies on the composition of marine sediments, rocks, and minerals will continue. In studies of marine geological and hydrological conditions and processes emphasis will be placed on the development of instrumentation for measuring the discharge of fresh-water from land through the ocean floor and for determining composition of sediments *in situ*.

Bureau of Mines

(Funds reported under Ocean Engineering)

The instrumentation program of Mines assists in the development of ocean floor mining systems, and of exploratory tools for resource development. The FY 1967 effort will be focused on the development of tools and equipment to delineate and evaluate continental shelf mineral reserves, especially shoreline deposits. Primary emphasis will be on the development of a neutron activated device for semi-quantitative analysis of sea bottom materials *in situ*. Other efforts will be directed to the evaluation of presently available flow rate meters and pipeline pulp density measuring devices for use in a marine environment.

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DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Federal Water Pollution Control Administration

FY 1965—$ 0*
FY 1966—$417,000*
FY 1967—$300,000*

The FY 1967 instrumentation expenditures are to be used largely by the Hudson-Champlain and Metropolitan Coastal Comprehensive Water Pollution Control Project. Instruments will be acquired to study water movement, water quality, and marine biology in estuarine and nearshore areas.

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NATIONAL SCIENCE FOUNDATION

($400,000 Reported under Research)

In the past year the following three grants were included for instrument development: A deep ocean device was designed to obtain punched

*Federal Water Pollution Control Administration programs for FY 1965-1966 are presented separately from Public Health Service for program comparison purposes. PHS expenditures were $45,000 in FY 1965 and again in FY 1966. Expenditures for instruments in FY 1967 were $0 for PHS. However, water pollution control activities were removed from Public Health Service December 31, 1965, and placed under a newly established Administration. FWPCA's first separate budget was prepared for FY 1967.

cores, after reaching a desired penetration, by jutting the tool through ocean bottom sediments; A two-stage piston corer and rotating piston corer are being designed to obtain longer cores and for recovery of hard rock; inexpensive deep-sea free vehicles are being developed for collecting fish, recording currents, gaging sediments, and measuring temperature.

In FY 1967, NSF will allocate approximately 15% of their total grants for research in oceanography to instrumentation for private and academic institutions, and other organizations. This amount ($400,000) is not included in the Instrumentation Budget. In addition NSF will reserve a portion of their recipients' grants to procure instruments from industry for their research programs.

INSTRUMENTATION FUNDED THROUGH OTHER CATEGORIES

In order to determine the actual expenditures in instrumentation, the items in parenthesis in the "Planned Expenditures Chart" represent the funds allocated in this area from the research, survey, and engineering budgets. The total of these funds is $4,826,000.

Table F
Planned Expenditures for Oceanographic Instrumentation FY 1967
(in thousands)

ACTIVITY	DEVELOPMENT		SERVICES		PROCUREMENT		TOTALS
	Item	Requested	Item	Requested	Item	Requested	
DEFENSE DEPT.		2,400				3,623	6,023
NAVOCEANO		2,000				2,683	4,683
In-House							
	Environmental sensor R&D	75					
	Development of standards and evaluation	100					
	Instrumentation for test and evaluation	20					
	Buoy systems	110					
	Fail safe recovery devices	100					
Other Agency							
	Fail safe recovery devices	150					
	Salinity-temperature calibration system	75					
Industry	Develop instruments for test and evaluation	300			Instruments and equipment for new ships	2,683	

Planned Expenditures for Oceanographic Instrumentation FY 1967—Continued
(in thousands)

ACTIVITY	DEVELOPMENT		SERVICES		PROCUREMENT		TOTALS
	Item	Requested	Item	Requested	Item	Requested	
DEFENSE DEPT. (Cont)							
(NAVOCEANO - Cont)							
Industry	Ships of opportunity	300			Research instruments	(212)[1]	(212)[1]
	Deep expendable ocean sonde	345					
	Shipboard Survey System II	200					
	Moveable platform for 60-foot test tank	75					
	Dissolved oxygen test system	75					
Univ. or Institution	Low speed flow calibration tank	75					
						940	940
ONR							
Industry					Buoys and buoy equipment	940	
Univ. or Institution					Research instruments	(3,400)[1]	(3,400)[1]
ARPA	Ocean bottom seismometry	400					400

[1]Parentheses, (), indicate estimated amount of research funds spent on instrumentation. The totals of these items do not appear in the *Instrumentation Budget*.

DEPT. OF COMMERCE		100.0		650	750
ESSA					
Coast and Geodetic Survey		90.0		616	706
In-House	Shipboard data acquisition system	(440)[1]			(737)[1]
	Deep-sea tide gauge system				
	Buoy development				
	Hydrographic survey system				
Industry	Shipboard data acquisition system	(297)[1]	Shipboard satellite navigation equipment	85	
	Deep-sea tide gauge system		Tide data acquisition and processing equipment	44	
	Buoy development				
	Hydrographic survey system				
	ODESSA buoy network	90			

[1]Parentheses, (), indicate estimated amount of research funds spent on instrumentation. The totals of these items do not appear in the *Instrumentation Budget*.

Planned Expenditures for Oceanographic Instrumentation FY 1967—Continued
(in thousands)

ACTIVITY	DEVELOPMENT		SERVICES		PROCUREMENT		TOTALS
	Item	Requested	Item	Requested	Item	Requested	
COMMERCE (cont'd)							
ESSA							
C&GS					Telemetering current system	337	
					Equipment for facilities	150	
Institute for Oceanography		10				34	44
In-House	Planetary boundary layers sensor systems	(25)[1]					(101)[1]
Industry	Aircraft sensors	10			Receiver-recorders	(21)[1]	
					Expendable sensors	34	
Institutions	Shipboard meteorological systems	(40)[1]					
Other agency	Microwave humidity sensor	(15)[1]					
DEPT. of HEALTH, EDUCATION AND WELFARE		20				280	300
FWPCA		20				280	300

[1]Parentheses, (), indicates estimated amount of research funds spent for instrumentation. The totals of the items do not appear in the *Instrumentation Budget.*

DEPT. OF HEW (cont'd)						
In-House	Development of current metering devices	20				
FWPCA						
Industry				Instruments for estuarine and near-shore water quality determination	280	
DEPT. OF INTERIOR		410		85	568	1,063
Bureau of Commercial Fisheries		385		75	440	900
In-House	Assist in development of projects of other organizations to ensure compatibility with BCF requirements.	6	Coordination and information exchange	54		
			Maintenance of miscellaneous instrumentation systems	21		
	Fish pump in combination with electro/light attraction	10				
	Miscellaneous instrumentation and fishing gear	19				
Industry	Fish finding sonar	190			Miscellaneous instruments and instrumentation systems	79
	Egg counter	30				
	Scale reader	30				

Planned Expenditures for Oceanographic Instrumentation FY 1967—Continued
(in thousands)

ACTIVITY	DEVELOPMENT		SERVICES		PROCUREMENT		TOTALS
	Item	Requested	Item	Requested	Item	Requested	
DEPT. OF INTERIOR (cont'd)							
BCF							
Industry	Thermographs, dual channel, with pressure for commercial trawls	30			Equipment for UNDAUNTED	83	
	Fish net bathykymographs	40			Acoustical devices	56	
	Plankton nets	20			Transducers and experimental net for trawl	51	
	Nekton sampler	10			Buoy equipment	45	
					S.D.T.	35	
					Fluorometers and circulation detectors	27	
					Fishing gear	10	
					Bathythermographs and thermographs	17	
					Salinity recorders	10	
					Oxygen analyzer	10	
					Atomic absorption spectrophotometer	8	
					Bottom and water samplers	8	
					Reversing thermometers	1	
Other Agency			Calibration of reversing thermometers	(2)[1]			

[1]Parentheses, (), indicates estimated amount of research funds spent for instrumentation. The totals of the items do not appear in the *Instrumentation Budget*.

DEPT. OF INTERIOR (cont'd)						
BSF&W					25	25
Industry				Sampling equipment for marine life and environment and analytical instruments	25	
Geological Survey		25		10	103	138
In-House and Institutions	Continuous sensing and recording devices to measure geochemical and geophysical properties of bottom sediments and associated waters. Self-contained portable geochemical laboratories; improved bottom sampling and photographic equipment; computer programming.	25	Maintenance of laboratory instruments	10		
Industry				Shipboard and shore laboratory equipment	103	((75))[2]
BuMines Industry				Ocean engineering instruments	((75))[2]	

[2]Double parentheses, (()), indicates estimated amount of ocean engineering funds spent on instrumentation. The totals of these items do not appear in the *Instrumentation Budget*.

Planned Expenditures for Oceanographic Instrumentation FY 1967—Continued
(in thousands)

ACTIVITY	DEVELOPMENT		SERVICES		PROCUREMENT		TOTALS
	Item	Requested	Item	Requested	Item	Requested	
TREASURY DEPT.				126		175	301
Coast Guard				126		175	301
In-House			Instrument maintenance	101			
Other Agency			Instrument calibration	15			
Universities or Institutions			Instrument calibration	10			
Industry					Instrument replacement	75	
					Two *in-situ* sensor systems for offshore light towers	100	
NATIONAL SCIENCE FOUNDATION		(200)[1]				(200)[1]	(400)[1]
Universities or Institutions	Research Instrumentation	(200)[1]					
Industry					Instrumentation for research	(200)[1]	
Budget Total		2,930		211		5,296	8,437
Totals Not in Budget		937		2		3,887	4,826
Grand Total		3,867		213		9,183	13,263

[1]Parentheses, (), indicates estimated amount of research funds spent for instrumentation. The totals of the items do not appear in the *Instrumentation Budget.*

C. Facilities

FY 1965—$5,984,000
FY 1966—$3,483,000
FY 1967—$5,228,000

Since inception of the National Oceanographic Program in 1961, the Interagency Committee on Oceanography has emphasized the need for the growth of the physical plants at academic and private institutions, as well as the in-house capabilities of Federal laboratories. By FY 1967 the government will have spent since FY 1961, a total of $36,618,000 on oceanographic facilities with approximately 52% going into government facilities, and 48% to academic and private institutions. This close balance results from parallel funding trends for both the academic and Federal sectors.

It should be noted that the funding of academic facilities can be considered as an investment in a future source of oceanographers and other related talents, as well as fostering the necessary environment for oceanographic research. We can look with pride at the quantity and excellence of the institutional facilities supported over the past six years by the agencies of the Federal government. Facilities under construction or recently completed represent some of the finest oceanographic centers ever designed and, although modest in size, offer complete supporting services to the research scientists.

Sixty-seven percent of the FY 1967 facilities budget will be allocated for construction of private and institutional laboratories, with the remaining funds supporting governmental facilities to be used for existing programs. Past budgets fluctuated widely, since there is usually a hiatus between design and construction funding. FY 1967 compares favorably with the funding trend developed over the past six fiscal years.

DEPARTMENT OF INTERIOR

Bureau of Commercial Fisheries

FY 1965—$2,500,000
FY 1966—$ 210,000
FY 1967—$ 160,000

The Bureau proposes to construct a $160,000 seawall and bridge at the Biological Laboratory, Beaufort, North Carolina to facilitate ship and logistic support operations.

* * *

Geological Survey

FY 1965—$20,000
FY 1966—$20,000
FY 1967—$20,000

Shore laboratories have been established at the Woods Hole Oceanographic Institution to support the East Coast Continental Shelf activities. Laboratory facilities to perform mineralogical and sedimentological analyses are being prepared on the West Coast.

During FY 1967 the Geological Survey will continue development of the marine research laboratories at its Menlo Park, California research center, and the Bureau of Commercial Fisheries Fishery-Oceanography Center on the campus of the Scripps Institution of Oceanography, La Jolla, California. Development of portside facilities for shipping and receiving samples and equipment on the West Coast will begin.

Bureau of Mines

FY 1965—$0
FY 1966—$25,000
FY 1967—$25,000

In FY 1967, construction is required for improvement of the Bureau's oceanographic laboratory at the Marine Mineral Technology Center at Tiburon, California.

* * *

NATIONAL SCIENCE FOUNDATION

FY 1965—$2,500,000
FY 1966—$2,500,000
FY 1967—$2,900,000

The National Science Foundation will continue to respond to proposals for facility construction and improvement. Last year the Foundation supported construction or modification of shore

facilities at academic and private institutions; among these were the University of California, Columbia University, University of Georgia, Scripps Institution, University of Chicago, Massachusetts Institute of Technology, University of North Carolina, Woods Hole Oceanographic Institution, and the University of Washington. Pressing needs still exist at some institutions, including the construction of additional research laboratories docks and wharfs, storage buildings, and machine shops. Precisely what facility grants will be awarded in FY 1967 will be decided when proposals are received and evaluated.

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Public Health Service

FY 1965—$0
FY 1966—$ 194,000
FY 1967—$2,108,000

Funds for FY 1967 will be used to construct and equip two new Shellfish Sanitation Research Centers. The presently inadequate Pacific Northwest Shellfish Sanitation Center at Purdy, Washington will be replaced at a cost of $1,000,000. Additional office space and laboratories, primarily for high safety virology studies, will be constructed at the existing Shellfish Sanitation Research Center at Narragansett, Rhode Island for $1,108,000.

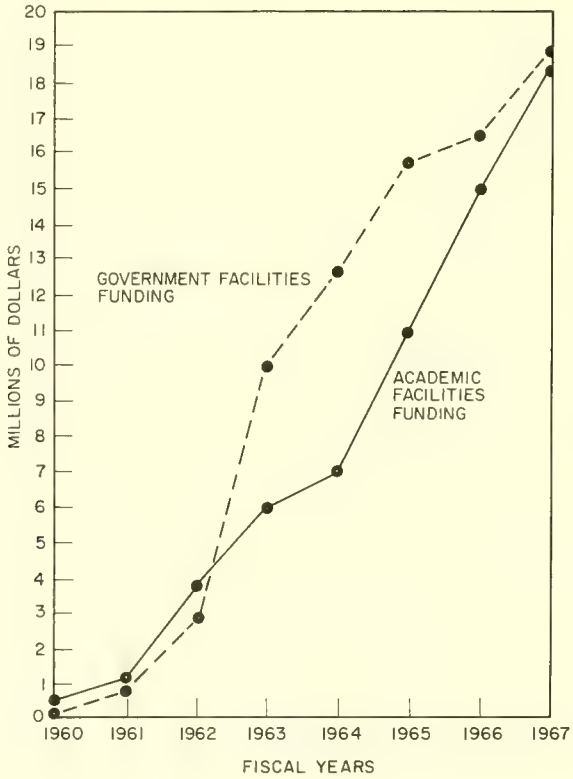
* * *

DEPARTMENT OF TREASURY

Coast Guard

FY 1965—$30,000
FY 1966—$30,000
FY 1967—$15,000

The Coast Guard will continue its program of constructing offshore light towers to replace lightship stations. One tower is planned in 1967. This facility will include an *in situ* sensor system and space for observation equipment of the Coast and Geodetic Survey, Corps of Engineers, and the Naval Oceanographic Office.



Cumulative Funding—Government and Academic—Fiscal Year 1960-1967

Table G
FACILITIES PROGRAM FY 1967
(In Thousands)

DEPARTMENT Agency	Purpose	Totals
HEALTH, EDUCATION, AND WELFARE		2,108
Public Health Service	Construction of replacement for Shellfish Sanitation Research Center, Purdy, Washington.	2,108 1,000
	Construction of addition to Shellfish Sanitation Research Center, Narragansett, Rhode Island.	1,108
INTERIOR		205
Bureau of Commercial Fisheries	Construction of seawall and bridge at the Biological Laboratory, Beaufort, North Carolina.	160
Geological Survey	Development of Marine Research Laboratories at Menlo Park and BCF Biological Laboratory, Scripps Institution of Oceanography, La Jolla, California.	20
Bureau of Mines	Improvements at Marine Mineral Technology Center, Tiburon, California.	25
NATIONAL SCIENCE FOUNDATION		2,900
	Grants to Universities, Institutions, and other organizations to construct facilities for physical and biological oceanographic research and education.	
TREASURY		15
Coast Guard	Construction of one Offshore Light Tower and Procurement of the Sensor System for an existing Tower.	15
TOTAL		5,228

II. OCEANOGRAPHIC SERVICES

National Oceanographic Data Center

FY 1965—$1,016,000
FY 1966—$1,180,000
FY 1967—$1,363,000

The operating costs of the National Oceanographic Data Center are for the acquisition, processing, archiving, and exchanging of oceanographic data. This amount is not the *total* national budget for data processing, as many agencies include the cost of data reduction and data processing required to fulfill their missions under such items as "Survey," and "Research." Funds in these categories are used to: (1) process data manually or automatically, on board ship or on shore, after completion of a survey; (2) request services (data and/or analytical) from existing archives such as the National Weather Records Center, Coast and Geodetic Survey (tidal data) and the World Data Center "A" (oceanography, magnetism, and gravity).

NODC is continuing its efforts in developing storage and retrieval systems to accommodate the many manuscript data accumulations. Systems for processing oceanographic station data, BT data (digital and analog), current (drift) data, certain geological data (information concerning core, dredge, and grab samples, and chemical analyses of bottom sediments); and certain biological data (phytoplankton, primary productivity, zooplankton, and benthos) already are operational. Systems for processing certain other types of physical and chemical data (coastal station data, non-nutrient chemistry data, expendable BT data) and geological data (engineering properties, underwater photography) will undergo final testing in FY 1966 and are scheduled to be operational in FY 1967. Developmental work is also planned to derive systems to process and archive additional marine geological and biological information and wave and ice data.

Automation of quality control methods will continue to be stressed and extended to cover a variety of data types. By FY 1967, it is anticipated that systems for comparing oceanographic data with mathematical models will be in the testing stage. Implementation of these methods hopefully would take place late in FY 1967 or early FY 1968. Simple automated quality control methods currently in use will become more refined and definitive by FY 1967; older systems as well as systems developed in FY 1966 will be expanded to take care of a broader spectrum of oceanographic data.

Evaluation, repunching, and editing of surface data from H-19 ledgers will be completed during FY 1967. Emphasis will also be on the editing and quality checking of oceanographic data received from the various ship of opportunity programs.

Table H
AGENCIES SUPPORTING THE NATIONAL OCEANOGRAPHIC DATA CENTER

	FY 1965	FY 1966	FY 1967
U.S. Navy	$472,000	$588,000	$622,000
U.S. Army	13,000	13,000	18,000
Environmental Science Services Administration	192,000	222,000	259,000
Bureau of Commercial Fisheries	167,000	167,000	167,000
Geological Survey	10,000	10,000	10,000
National Science Foundation	100,000	100,000	200,000
Atomic Energy Commission	37,000	37,000	37,000
Public Health Service	—	5,000	5,000
Federal Water Pollution Control Administration	—	6,000	6,000
U.S. Coast Guard	25,000	32,000	39,000
TOTAL	$1,016,000	$1,180,000	$1,363,000

III. MANPOWER AND TRAINING

Professional oceanographic staffs are drawn from many disciplines, and manpower statistics for oceanography are difficult to assess. The most recent nation-wide survey (1964) showed about 3,000 professionals engaged in oceanographic work, of which 700 were identified as research oceanographers in terms of education and work experience.[1]

Exclusive of ocean engineering, budget plans for FY 1967 indicate a 10 percent increase over 1966 and staff increases are expected in the same proportion. Such increases will continue to require recruitment from allied disciplines accompanied by in-service training in oceanography.

Deployment of Oceanographic Staff

Principal employers of oceanographic staff are the Federal Government, colleges and universities, State and local governments, private industry, and miscellaneous nonprofit institutions.[2] The accompanying Table I presents an estimated percentage distribution of oceanographers and professional staff engaged in oceanographic work by type of employer.

Manpower Implications of the FY 1967 National Oceanographic Program

Since FY 1964 Federal obligations for oceanographic research and surveys increased from $85 million to $97 million in 1965, to $109 million in 1966, and to an estimated $121 million in 1967.

This represents a 1967 expenditure level for research and surveys of 42 percent over 1964.[3]

[1]See *Scientific and Technical Personnel in Oceanography*, ICO Pamphlet No. 21. This report, revised and edited by the Interagency Committee on Oceanography, contains the results of a survey conducted by the International Oceanographic Foundation under contract (C-331) with the National Science Foundation.

[2]*Ibid.*, pp. 12, 13.

[3]Ocean engineering program obligations are not included in the base since they reflect, to a great extent, construction and equipment contracts. Although these engineering obligations may imply the general direction of personnel requirements, they are not a good indication as to quantity.

Table I
Estimated Percent Distribution of Research Oceanographers and Oceanographic Staff by Type of Employer, 1964

Type of Employer	Percent Distribution: Research Oceanographers	Percent Distribution: Oceanographic Staff
Total	100	100
Federal Government	29	32
Colleges and universities	50	28
State and local governments	7	8
Industry	4	8
Miscellaneous nonprofit	7	5
Other	4	3
Students[a]	—	17
	N=700	N=3,000

[a]Includes graduate students, many of whom are employed part-time in university research.

Manpower requirements for FY 1967, therefore, should increase by roughly one-third over the 1964 figure. Although these requirement estimates are closely related to research and survey expenditures, the variance here (33% *vs.* 42%) is best explained by increased costs of ship operation and equipment which are also included in research and survey budgets. The net result is to approximate total professional staff requirements in the vicinity of 4,000 by the end of FY 1967.

Manpower Supply

The academic training and technical backgrounds of oceanographic staff are extremely varied as shown in *Scientific and Technical Personnel in Oceanography.* Although advanced degrees in oceanography seem to be preferred qualifications, those working in oceanography frequently hold advanced degrees in biology, geology, or other sciences.[4] Others hold only bachelor's degrees in science or engineering.

Although significant growth in potential manpower supply is evidenced by 763 graduate enrollments at the end of calendar year 1965 (as compared with 547 for 1963), actual manpower supply from oceanographic degree holders is smaller than present program requirements and makes necessary the continuing recruitment of staff from fields of biology, geology, engineering, *etc.* as in the past. The general increase in college graduates with scientific degrees facilitates such transfers. So long as opportunities in oceanography continue to attract staff from the other sciences, there is relatively little difficulty in meeting requirements in the quantitative sense. Recruitment from these sources does require a significant program of supplemental training to make effective use of such recruits.

Federal Government Support of Training in Oceanography

Federal support for graduate training in oceanography may be classified as (1) fellowships and traineeships awarded for graduate training; (2) formal programs to provide supplementary education and training to Federal employees; and (3) research grants and contracts to universities which employ graduate students as research assistants.

The extent of Federal agency programs of these types is shown in the accompanying Schedules 1, 2, and 3, which show estimated 1967 obligations of $1,474,000 in addition to 690 man-years of graduate student support through research grants and contracts.

[4] *Scientific and Technical Personnel in Oceanography,* ICO Pamphlet No. 21, pp. 33, 34.

Estimated Agency Obligations for Education and Training in Oceanography
Fiscal Years 1965, 1966, 1967

Schedule 1 — Fellowships and Traineeships

	Obligations (000)			Graduate Fellows or Trainees to be Supported: Man-Years or Man-Academic Years			Graduate Fellows or Trainees to be Supported: Number of Individuals		
	1965	1966	1967	1965	1966	1967	1965	1966	1967
Total	$699	$811	$1,012	101	121	152	195	193	225
Department of Interior									
Bureau of Commercial Fisheries	195	195	195	41	41	40	48	42	42
Geological Survey	—	—	5	—	—	1	—	—	1
National Science Foundation[a]	337	314	397	30	30	40	116	100	110
Department of Health, Education, and Welfare									
Office of Education	77	165	264	14	26	45	14	26	45
Federal Water Pollution Control Administration	90	137	151	16	24	26	17	25	27

[a]Includes fellowships, traineeships, institutes for college teachers, and research participation programs.

Estimated Agency Obligations Data for Education and Training in Oceanography
Fiscal Years 1965, 1966, 1967

Schedule 2 — Training of Federal Personnel[a]

	Obligations (000)			Man-Months of Training to be Provided			Number of Individuals to be Trained		
	1965	1966	1967	1965	1966	1967	1965	1966	1967
Total	$323	$426	$478	477	595	661	291	319	326
Department of Defense									
Department of the Navy									
Oceanographic Office[b]	121	209	239	104	209	232	56	73	81
Other Navy Activities[c]	52	56	82	40	44	63	33	34	38
Department of the Army									
Corps of Engineers[d]	8	9	10	15	17	25	8	9	10
Department of Commerce									
ESSA	77	85	86	166	183	185	105	115	116
Department of the Interior									
Bureau of Commercial Fisheries	20	20	20	80	80	80	70	70	70
Bureau of Sport Fisheries and Wildlife	15	6	6	42	18	18	5	2	2
U.S. Geological Survey	5	5	5	4	4	4	9	9	4
Department of the Treasury									
Coast Guard[e]	25	36	30	26	40	54	5	7	5

[a] Civilian personnel only, except as noted.

[b] Not included are obligations (000) of approximately $13, $15, and $18 in 1965, 1966, and 1967, for after-hours courses in Marine Science. In 1965, 216 persons participated in such courses.

[c] Includes graduate education in oceanography for naval officers at the Navy Post-Graduate School and at civilian universities.

[d] Includes junior officer training and quartermaster surveyor training.

[e] Figures cover officers and professional civilians. Not included are an enlisted man's oceanographic technician training school funded from ocean survey funds and involving in 1965 and in 1966: Obligations (000) $100, Man-Months — 160, Individuals (Military) — 80; and in 1967: Obligations (000) $53, Man-Months — 120, Individuals (Military) — 60.

Estimated Agency Obligations Data for Education, and Training in Oceanography
Fiscal Years 1965, 1966, 1967

Schedule 3 — Research Grants and Contracts

	Graduate Students Supported					
	Number of Man-Years or Man-Academic Years			Number of Individuals		
	1965	1966	1967	1965	1966	1967
Total	482	576	690	520	601	753
Department of Defense						
Department of the Navy						
Office of Naval Research	83	86	95	145	150	230
Other Navy Activities	20	22	22	42	49	49
Department of the Army						
Corps of Engineers	6	7	8	13	15	17
Department of the Interior						
Bureau of Commercial Fisheries	4	5	5	8	10	10
Bureau of Sport Fisheries and Wildlife	2	2	4	2	2	4
National Science Foundation	286	362	453	195	241	292
Atomic Energy Commission	50	55	60	80	90	100
Department of Health, Education and Welfare						
Federal Water Pollution Control Administration	24	28	30	24	28	30
Smithsonian Institution	6	8	12	10	15	20
Department of the Treasury						
Coast Guard	1	1	1	1	1	1

APPENDIX

Inventory of Research/Survey Vessels in the U.S. Oceanographic Fleet

NAVY SURVEY/RESEARCH SHIPS

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
TANNER CLASS									
TANNER	426	17	53	6,500	330	8	AKA	1944	Precise coastal surveys. Serves as operating tender providing support for smaller ships, sound boats and shore parties. Equipped with helicopers, chart production capability and electronic positioning equipment.
MAURY								1943	
SAN PABLO CLASS									
SAN PABLO	300	13	41	2,600	174	8	AVP	1942	Deep-water oceanographic and hydrographic data. Basic ship for collection of deep-ocean environmental data for pro and antisubmarine warfare.
REHOBOTH									
BOWDITCH CLASS									
BOWDITCH	455	24	62	13,000	80	15	CARGO	1944	Deep ocean surveys for special fleet requirements.
DUTTON									
MICHELSON									
REQUISITE CLASS									
TOWHEE	221	11	32	1,250	82	2	AMS	1941	Nearshore, shallow and medium depth hydrographic and oceanographic work, either for charting surveys or for special military projects such as mining and mine counter measures work; mid depth equipment test and evaluation; shipborne and bottomed sonar arrays.
SHELDRAKE									
SERRANO CLASS									
SERRAN	195	15	39	1,235	82	2	ATF	1943	
LITTLEHALES	136	11	31	600	19	1	YF	1945	(N) Coastal oceanography for military requirements.
MIZAR (AGOR-11)	266	18	51	3,000	39	12	AK	1964	Basic and applied oceanography for Naval Research Laboratory.

NAVY SURVEY/RESEARCH SHIPS—Continued

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
ARCHERFISH (Submarine)	311	17	27	2,220	55	4	SS	1943	Oceanographic surveys.
GILLISS CLASS (AGOR)									
GILLISS	209	14	41	1,320	26	15	New	1963	Basic and applied oceanography; acoustic test of environmental effects on instruments. SPECIAL FEATURES: Lab and office space, acoustic silencing, oceanographic winches, deep anchoring, bow propeller, anti-roll tanks, van storage.
CONRAD								1963	
DAVIS								1963	
SANDS								1964	
LYNCH								1965	
THOMPSON								1965	
WASHINGTON								1965	
DESTEIGUER								1967	
BARTLETT								1967	
New Design AGOR									
AGOR	239	15	46	1966	25	25	New	1968	
AGOR								1968	
KELLAR CLASS									
KELLAR (small AGS)	209	14	41	1,350	26	15	New	1966	Same as REQUISITE Class
SILAS BENT CLASS (Medium AGS)									Same as SAN PABLO Class
SILAS BENT	280	15	48	2,550	41	34	New	1965	
KANE								1966	
Proposed FY 67 Program									
1 large AGOR (Private Lab)							New	1970	Large AGOR specifically designed to support ASW oceanographic research (cost—$13,800,000).

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC*	SOURCE	AGE	MISSION
CLASS I									
SURVEYOR	292	16	49	3,150	40	66	New	1960	Complex oceanographic capability.
OCEANOGRAPHER	303	18	52	3,805	42	64	New	1966	Complex oceanographic capability.
DISCOVERER	303	18	52	3,805	42	64	New	1966	Complex oceanographic capability.
NOT NAMED	278	18	51	2,900	34	42	New	1968	Complex oceanographic capability.
CLASS II									
EXPLORER	220	16	38	1,900	39	56	New	1940	Hydrography and limited oceanography.
PATHFINDER	229	16	39	2,000	39	56	New	1942	Hydrography and limited oceanography.
MT. MITCHELL	231	14	42	1,794	36	40	New	1967	Hydrography and limited oceanography.
FAIRWEATHER	231	14	42	1,794	36	40	New	1967	Hydrography and limited oceanography.
RAINIER	231	14	42	1,794	36	40	New	1967	Hydrography and limited oceanography.
CLASS III									
PEIRCE	163	10	33	760	25	11	New	1963	Hydrography and limited oceanography.
WHITING	163	10	33	760	25	11	New	1963	Hydrography and limited oceanography.
HYDROGRAPHER	165	15	32	1,106	35	29	New	1930	Hydrography and limited oceanography.
BOWIE	136	8	24	267	23	5	PCS	1943	Hydrography and limited oceanography.
HODGSON	136	8	24	289	23	6	PCS	1943	Hydrography and limited oceanography.
DAVIDSON	175	12	38	890	25	11	New	1967	Hydrography and limited oceanography.
MC ARTHUR	175	12	38	890	25	11	New	1967	Hydrography and limited oceanography.
CLASS IV									
PATTON	88	8	21	150	14	1	New	1941	Hydrography and limited oceanography.
LESTER JONES	88	8	21	150	14	1	New	1944	Hydrography and limited oceanography.
MARMER	107	10	22	220	15	2	Cutter	1932	Hydrography and limited oceanography.
RUDE	90	6	22	173	7	3	New	1966	Wire drag boat for harbor and waterway obstruction surveys.
HECK	90	6	22	173	7	3	New	1966	Wire drag boat for harbor and waterway obstruction surveys.

*Includes technical complement.

Above list does not include two existing wire drag boats, each with a displacement of less than 100 ton.

Proposed FY 1967 Program

1 Continental Shelf Current Survey Ship	New	1970	Replacement for MARMER (Cost—$1,689,000)

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
"SECRETARY" CLASS									
INGHAM	327	15	41	2,827	125	–	WPG	1937	Ocean station vessels equipped with oceanographic winches and laboratory space.
SPENCER									
CAMPBELL									
TANEY									
BIBB									
DUANE									
SEAPLANE TENDER									
CASCO	311	14	41	2,800	125	–	WAVP	1943	Ocean station vessels equipped with oceanographic winches and laboratory space.
YAKUTAT									
HUMBOLDT									
COOK INLET									
CASTLE ROCK									
BARATARIA									
GRESHAM									
BERING STRAIT									
ROCKAWAY									
CHINCOTEAGUE									
ABSECON									
HALF MOON									
McCULLOCH									
"LAKE" CLASS									
MENDOTA	255	14	42	1,913	125	–	WPG	1944	Ocean station vessels equipped with oceanographic winches and laboratory space.
ESCANABA									
MINNETONKA									
PONCHARTRAIN									
SEBAGO									
ANDROSCOGGIN									

U.S. COAST GUARD — Continued

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
"LAKE" CLASS — Continued									
CHAUTAUQUA									
KLAMATH									
OWASCO									
WACHUSETT									
WINNEBAGO									
WINONA									
EVERGREEN	180	13	33	1,000	48	3	WLB	1943	Buoy tender with oceanographic capability.
EASTWIND	269	29	63	6,500	234	10	WAGB	1945	Icebreaker with oceanographic capability.
NORTHWIND									
WESTWIND									
EDISTO									
GLACIER	310	28	74	8,300	240	10	WAGB	1955	Icebreaker with oceanographic capability.

Proposed FY 1967 Program

Design study and detailed plans.

EVERGREEN Replacement
(Cost — $500,000)

NATIONAL SCIENCE FOUNDATION

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
ELTANIN	266	20	51	3,800	47	38	Conversion	1957	Oceanographic Research.
ANTON BRUUN	243			1,700	32	24	Conversion	1930	
ATLANTIS II	Listed with WHOI						New	1962	
PILLSBURY	Listed with U. of Miami						Conversion	1943	
ALAMINOS	Listed with Texas A&M						Conversion	1944	
YAQUINA	Listed with Oregon State U.						Conversion	1944	
EASTWARD	Listed with Duke University						New	1965	
Catamaran	To be delivered to CBI (Johns Hopkins)						New	1967	
TE VEGA	Listed with Stanford University						Conversion	1930	
INLAND SEAS	Listed with U. of Michigan						Conversion	1944	
ALPHA HELIX	Listed with Scripps						New	1965	
TERRITU	Listed with U. of Hawaii						Conversion	1954	

In addition to above list of major vessels smaller boats have been supplied to other institutions.
NOTE: This inventory partially duplicates those ships listed under "Private Institutions."

Proposed FY 1967 Program

Arctic Research Platform Design Study (Cost—$200,000)

BUREAU OF COMMERCIAL FISHERIES

TYPE	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
ALBATROSS IV	187	11	33	1,000	19	12	New	1963	Ocean research; biology, chemistry, meteorology, and fisheries.
CHARLES H. GILBERT	123	11	21	383	11	5	New	1952	
TOWNSEND CROMWELL	158	10	33	600	13	10	New	1964	
GEORGE B. KELEZ	167	10	30	500	12	6	Conversion	1944	
BLACK DOUGLAS	152	14	32	371	11	5	Conversion	1938	
DELAWARE	147	15	25	518	13	4	Conversion	1950	
GERONIMO	147	15	33	760	15	10	Conversion	1945	
UNDAUNTED	147	15	33	760	15	12	Conversion	1945	
DELAWARE replacement	150	12	30	650	13	6	New	1966	
DAVID STARR JORDAN	171	11	37	714	22	13	New	1965	
MILLER FREEMAN	200	16	42	1,200	20	9	New	1966	
MURRE II	86	5	35	250	4	5	Conversion	1943	
JOHN N. COBB	93	10	25	250	11	4	New	1950	
OREGON	100	10	26	219	11	3	New	1946	
OREGON replacement	170	13	34	600	14	10	New	1967	
Not Named (For Gulf of Mexico)	84	—	—	180	—	—	New	1966	

Approximately 10 BCF ships with a displacement of less than 100 tons not listed above.

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
SMITHSONIAN INSTITUTION									
PHYKOS	134	8	30	650	3	8	Conversion (YF)		Research on continental shelf organisms.
BUREAU OF SPORT FISHERIES & WILDLIFE									
DOLPHIN	107	12	25	390	9	5	Conversion	1953	Sport fishery research.
BUREAU OF MINES									
PERSPICACITY	65	6	18	95	3	9	Conversion	1953	Marine mining research.
AN-80	168	10	33	785	12	9	Conversion	1945	Marine mining research.

PRIVATE INSTITUTIONS

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
UNIVERSITY OF WASHINGTON									
BROWN BEAR	114	13	27	750	11	21	Conversion	1934	Oceanographic research and student training.
HOH	65			91		8	Conversion	1943	
THOMPSON (AGOR)		Listed with Navy Research Ships							
SCRIPPS INSTITUTION OF OCEANOGRAPHY									
AGASSIZ	180	10		825	18	14	Conversion	1944	Oceanographic research (biology, chemistry, meteorology, fisheries, seismology, instrument development, student training).
ARGO	213	15	40	2,079	40	24	ARD	1944	
HORIZON	143	14	33	900	18	14	ATA	1944	
OCONOSTOTA	102	12		206	10	4	Conversion	1944	
PAOLINA-T	20	10	22	170	9	5	Conversion	1944	
WASHINGTON (AGOR)		Listed with Navy Research Ships							
ALPHA HELIX	133	11	31	512	22		New	1965	Biological oceanography.
AGOR (New Design)		Listed with Navy Research Ships						1968	
OREGON STATE UNIVERSITY									
YAQUINA	180			820	18	14	Conversion	1944	Oceanographic research.
TEXAS A&M COLLEGE									
ALAMINOS	180			740	18	14	Conversion	1944	Oceanographic research.
UNIVERSITY OF MIAMI									
GERDA	75	10	21	135	3	5	Conversion	1948	Oceanographic research.
J. E. PILLSBURY	177			935		20	Conversion	1943	

PRIVATE INSTITUTIONS — Continued

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
UNIVERSITY OF ALASKA									
ACONA	80	9	22	154	6	8	Trawler	1961	Oceanographic research.
HUDSON LABORATORY									
JOSIAH GIBBS	300	15	42	2,800	48	24	AVP	1944	Oceanographic research (acoustics, chemistry, instrument development).
LAMONT GEOLOGICAL OBSERVATORY									
CONRAD (AGOR)		Listed with Navy Research Ships.							Oceanographic research and student training.
VEMA	200	17	33	734	19	17	Sailboat	1923	
NARRAGANSETT MARINE LABORATORY									
TRIDENT	180	10	32	856	18	13	Conversion	1944	Oceanographic research (acoustics, plankton, magnetics, bottom photography).
WOODS HOLE OCEANOGRAPHIC INSTITUTION									
ATLANTIS I	142	19	28	565	17	9	Ketch	1931	Oceanographic research (bathymetry, bottom photography, biology, chemistry, instrument development, and student training).
ATLANTIS II	210	16	44	2,100	28	25	New	1962	
CHAIN	213	15	41	2,100	29	23	ARS	1944	
CRAWFORD	125	12	24	322	15	8	CG Cutter	1927	
GOSNOLD	99			304			Conversion	1943	
AGOR (New Design)		Listed with Navy Research Ships						1968	

PRIVATE INSTITUTIONS—Continued

NAME	LOA	DRAFT	BEAM	DISPL	COMPLEMENT CREW	SC	SOURCE	AGE	MISSION
STANFORD UNIVERSITY									
TE VEGA	135	17	28	270	15	15	Conversion	1930	Oceanographic research.
NEW YORK UNIVERSITY									
KYMA	65		17	95			Conversion	1952	Oceanographic research.
UNIVERSITY OF MICHIGAN									
INLAND SEAS	85						Conversion	1944	Research Great Lakes.
UNIVERSITY OF HAWAII									
TERRITU	92	10	22				Conversion	1954	Oceanographic research.
DUKE UNIVERSITY									
EASTWARD	118	11	29	474	30		New	1965	Biological oceanography.

AUTHOR

TITLE

ICO PUBLICATIONS

No.			
1	Oceanographic Ship Operating Schedule, FY 1962	March, 1961	Superseded
2	National Oceanographic Program, FY 1962	March, 1961	Superseded
3	National Oceanographic Program, FY 1963	May, 1962	Superseded
4	Oceanographic Ship Operating Schedule, FY 1963	May, 1962	Superseded
5	Oceanographic Research in the Federal Government	June, 1962	Out of print
6	University Curricula in Oceanography 1962-63	June, 1962	Superseded
7	National Plan for Ocean-Wide Surveys	May, 1963	Out of print
8	Opportunities in Oceanography	July, 1964	Smithsonian Inst. $0.50
9	Bibliography of Oceanographic Publications	April, 1963	Out of print
10	Long Range National Oceanographic Plan (1963-1972)	June, 1963	
11	National Oceanographic Program, FY 1964	April, 1963	Superseded
12	Oceanographic Ship Operating Schedule, FY 1964	May, 1963	Superseded
13	Canceled		
14	University Curricula in Oceanography 1963-64	June, 1963	Superseded
15	National Oceanographic Program, FY 1965	March, 1964	Superseded
16	Oceanographic Ship Operating Schedule, FY 1965	May, 1964	Superseded
17	National Oceanographic Program, FY 1966	January, 1965	Superseded
18	Underseas Vehicles for Oceanography	December, 1965	GPO $0.65
19	Oceanographic Research in the Federal Government	September, 1966	In preparation
20	Bibliography of Marine Sciences Publications and Reports (1962-1964)	September, 1966	In preparation
21	Scientific and Technical Personnel in Oceanography in the United States	November, 1965	
22	Oceanographic Ship Operating Schedule, FY 1966	May, 1965	
23	University Curricula in Oceanography Academic Year 1965-66	December, 1965	
24	National Oceanographic Program, FY 1967	March, 1966	
25	U.S. Oceanic Research in Foreign Waters	January, 1966	Limited distribution

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