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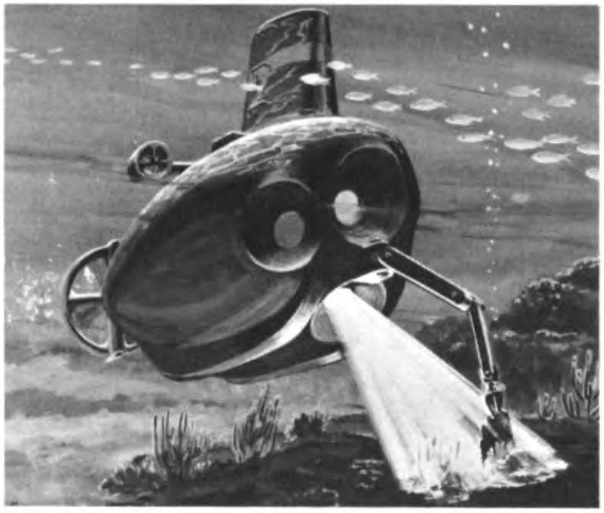
New Research Vessels . . .

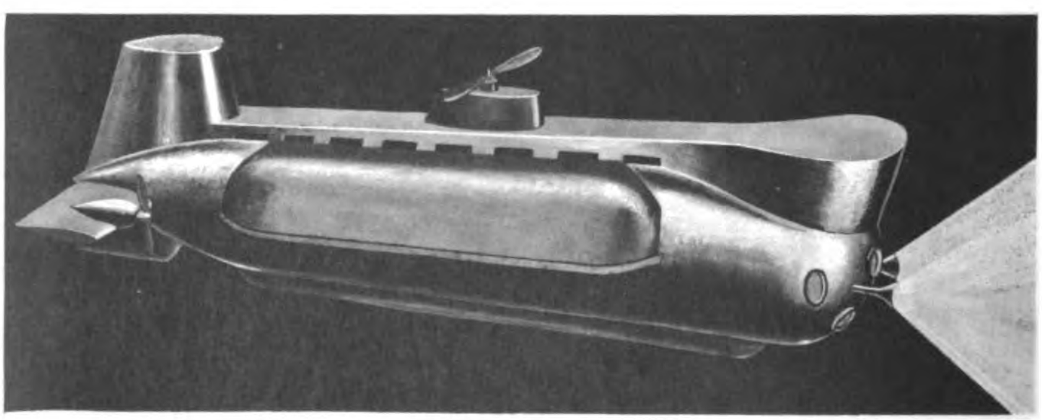
FLIP, a 355-foot-long manned research vessel now in ▶ operation in the Pacific Ocean. The tubular structure is seen in the act of submerging (on facing page) and in the stable vertical position (at right).



The 20-foot-long, 2-man submersible ALVIN, to be capable of exploring the ocean to depths of about 6,000 feet.

The ALUMINAUT, a 50-foot-long submersible expected to be capable of descending to a depth of 16,000 feet with a 3-man crew.

. . . Present and Future



OCEANOGRAPHY IN THE YEARS AHEAD

THIS SPECIAL ISSUE OF *Naval Research Reviews* DESCRIBES THE NAVY'S ROLE IN OCEANOGRAPHY OVER THE NEXT TEN YEARS, AS SPELLED OUT IN *Oceanography, the Ten Years Ahead: A Long-Range Oceanographic Plan, 1963-1972*, PREPARED BY THE INTERAGENCY COMMITTEE ON OCEANOGRAPHY OF THE FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY AND MADE PUBLIC IN JULY. WITH THE EXCEPTION OF THE INTRODUCTORY ARTICLE, BY ROBERT B. ABEL, ALL OF THE DISCUSSIONS APPEARING HERE ARE CONDENSED OR SLIGHTLY MODIFIED VERSIONS OF PORTIONS OF THE RECENT ICO PUBLICATION.

THE NATIONAL GOAL 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.*

SUBORDINATE GOALS:

Strengthening Basic Science
Improving National Defense
Managing Resources in the World Ocean
Managing Resources in Domestic Waters
Protecting Life and Property; Insuring the Safety of Operations at Sea

The ICO and the Long-Range Plan

Robert B. Abel
Executive Secretary
Interagency Committee on Oceanography

On March 29, 1961, President Kennedy forwarded to the Congress the National Oceanographic Program for the next fiscal year—the first formal submission by a President of a coordinated plan for all oceanographic activities of the Federal Government. In his message accompanying the program, the President wrote, "The seas around us . . . represent one of our most important resources. If vigorously developed, this resource can be a source of great benefit to the Nation and to all mankind."

The President's program first began to take form several years earlier when Government agencies and the scientific community collaboratively called attention to the importance of oceanography and oceanographers to the Nation. The National Academy of Sciences' Committee on Oceanography, through its ten-volume report—"Oceanography 1960-1970"—pinpointed problems needing to be solved in the marine sciences and evaluated the impact of the oceans upon our country's welfare. In recognition of this mounting concern, the Federal Council for Science and Technology, in 1959, formed a subcommittee on oceanography, which in 1960 was formally named the Interagency Committee on Oceanography (ICO).

As outlined by the Special Assistant to the President for Science and Technology, the mission of the ICO is "to develop annually the national oceanographic programming, incorporating its best judgment as to balance and emphasis in terms of both long-range scientific needs and requirements of Government agencies . . ."

Partly in response to Congressional demands and partly based on his own recognition of the need to plan for the future of the marine sciences, the President's Special Assistant for Science and Technology asked the ICO to develop a long-range plan which would coordinate individual agency programs, and which would also prescribe the methods by which these programs could function in common cause through joint use of facilities, trained manpower, and the knowledge which had been and would continue to be gained. With this request, the Long-Range Oceanographic Plan was born.

From the beginning, the Navy has led the way in the study and preparation of the National Oceanographic Program. It has thus been involved actively in the work of the Interagency Committee on Oceanography, primarily through the ICO's Chairman, the Hon. James H. Wakelin, Jr., Assistant Secretary of the Navy (R&D), and the Committee's Executive Secretary—the author of this article—who is also on the staff of the Research Coordinator of the Office of Naval Research.

Not counting its classified military oceanographic interests (normally considered to lie outside the ICO "umbrella"), the Navy has charge of approximately 40 percent of the national program. It is particularly active in providing research support, conducting survey operations, and in the construction of ships. Its work is carried out by a number of technical Navy bureaus and offices, including the Office of Naval Research, Naval Oceanographic Office, Bureau of Ships, and

Bureau of Weapons. The Naval Oceanographic Office is responsible chiefly for surveying and mapping, and for developing techniques for forecasting oceanographic conditions affecting Naval operations. The Bureau of Ships conducts oceanographic investigations directed at the elucidation of ocean conditions and practices which affect the design of ships and equipment. The Bureau of Weapons' program seeks to determine the effect of the ocean environment upon weapon systems and weapon technology. The Office of Naval Research supports basic and applied oceanographic research programs; a great portion of this research has considerable effect upon, and relates closely to, the programs of a number of other Federal agencies.

Because the Navy is concerned primarily with defense and national security, and to a lesser extent with the other objectives stated in the plan, it is developing its own ten-year plan for oceanography, called TENOC. The first edition of this plan was prepared in 1958; the second, a more comprehensive version, two years later; and the third edition, the most detailed and all-encompassing of the series, is expected to be completed sometime this winter. TENOC's purpose is to outline the Navy's role in greater detail than is done in the national plan, covering particularly its responsibilities in military oceanography, which are not included in the broader outline. However, the plan is being written to fit as well as possible within the framework of the long-range plan.

As may well be appreciated, the Congress has been concerned during recent years that the Nation's oceanographic program, which is currently carried out by 22 Federal agencies, be coordinated as fully as possible. As a means of doing this, the suggestion has often been made that a unitized Federal structure, such as NASA, be established. Such an arrangement would be inappropriate, however, for the reason that oceanography is not an end in itself, but merely a means to an end—a tool by which a number of Federal agencies prosecute their basic missions. The Bureau of Commercial Fisheries, for example, needs to study the oceans to collect information on fish migrations and other phenomena affecting fish catches, and the Weather Bureau is interested in oceanography as a means of improving its forecasts. To deny ocean research to such agencies would handicap them severely in carrying out their missions. On the other hand, the opposite extreme of alternatives—a laissez-faire policy—would lead to confusion, duplication of effort, and considerable waste. The happy medium is achieved through the coordination of effort provided by the ICO—whereby the capabilities and operations of all Federal agencies interested in oceanography are guided toward common goals without affecting unfavorably the missions of each.

In addition to the ICO's Chairman and Secretary, identified in the article above, the Committee includes--

RADM H. ARNOLD KARO, Director, U.S. C&GS
DONALD L. MCKERNAN, Director, Bureau of Commercial Fisheries
RADM R. D. SCHMIDTMAN, Chief, Office of Operations, U.S. C&GS
HARVE J. CARLSON, Asst. Director, Biological and Medical Sciences, NSF
HARRY G. HANSON, Assoc. Chief, Bureau of State Services, PHS
JOHN N. WOLFE, Division of Biology and Medicine, AEC
I. E. WALLEN, Asst. Director for Oceanography, Museum of Natural History

--See also bottom of Page 18

The ARGO, an auxiliary re and salvage ship converted research by the Office of Naval search for the Scripps Institu of Oceanography

The Effort is Propitiously Divided

The long range projections set forth in the new oceanographic plan call for oceanographic budgets to grow about 10 - 11 percent annually on the average. This growth is expected to be about in pace with the national average for all of science and technology, faster during the next five years than in the subsequent five years, with annual expenditures rising to $350 million in FY 1972.

As compared with previous national oceanographic programs, some major changes in emphasis are embodied in the new plan—particularly the devotion of a larger proportion of the total effort to research. The greater emphasis on research reflects a general consensus that applied work demands a firmer footing on theory and empirical observation and broad understanding than now exists to permit even narrow questions of practical importance to be answered properly. Moreover, research conducted within the context of any single goal or agency mission by its nature contributes to the general pool of knowledge and inevitably finds application to other problems of other agencies. All together, about 56 percent of the projected effort over the decade will be basic research, with broad though incalculable implications for the applied work of all agencies in support of every national goal.

The programs in support of basic and applied oceanography are divided as follows:

SUPPORT OF BASIC SCIENCE; 1963-1972

(56 PERCENT OF TOTAL BUDGET—$1300 MILLION)

	(millions)
Navy	$ 465
National Science Foundation	500
Bureau of Commercial Fisheries	200
Geological Survey	40
Atomic Energy Commission	30
Public Health Service	30
Smithsonian Institution	25
Coast and Geodetic Survey, the Weather Bureau, the Bureau of Mines, the Bureau of Sport Fisheries, the Maritime Administration, and the Coast Guard	10

SUPPORT OF APPLIED OCEANOGRAPHY

(32 Percent of Total Budget—$750 Million)

	(millions)
The direct support of defense projects	$ 370
Problems of resource management and the control of health threats in the world ocean	190
Exploiting resources on and under the continental shelf	70
The protection of the U.S. public from local pollution and unfit seafood	70
Protecting life and property along the coasts and enhancing the safety of operations at sea.	50

The remaining 12 percent ($280 million) of the budget supports routine surveys and services of general utility to the entire oceanographic community.

Most of this effort is also highly beneficial to private groups with a special interest in the sea. Much of it is considered essential to the fishing industry, helpful to the shipping and recreation industries, desirable for the mining industry, and indispensable to the oceanographic scientists themselves. The oil industry has traditionally supplied its own oceanography.

Research tower ARGUS ISLAND erected by the Navy
30 miles southwest of Bermuda

Based on the current manpower projection, the ten-year comparison in capabilities and systems is planned to appear as follows:

	1963	1972
Ships	76	128
Major Laboratories	over 50	over 70
Professional Manpower	2700	over 6000

Major Goals

Each of us perceives the national interest in his own way, relating it—quite properly—to his own interest. In a democracy, the national interest is in fact a collective expression of regional, sectional, local, institutional, and individual interests, and as these evolve, change, and interact with each other and our environment so the national interest appears in a variable and shifting light. Nevertheless, something abides to which we all respond; the recent growth in oceanography from a ten-million-dollar enterprise involving only a few hundred professional workers in 1953 to one thirteenfold greater in 1963, pursued by a few thousand, demonstrates how greatly the seas have begun to evoke this response from present-day Americans.

Such figures, like the statements of public officials that oceanography is of vital importance to the Nation, the declared intention of Congress that the United States capability in this field be second to none, and the vigorous efforts of numerous representatives of the oceanographic community, such as the National Academy of Sciences Committee on Oceanography to promote a public awareness of oceanography's scientific and social significance, are indices—though not explanations—of the extent to which oceanography is related to the national interest. For an explanation we must turn to more specific and concrete matters, the goals and responsibilities of the Federal Government.

In pursuit of national goals, the Federal Government has assumed a number of specific responsibilities. Those relating to defense and the general welfare for which a knowledge of the oceans is particularly pertinent are shared by some 16 agencies and bureaus within almost all the major departments of the Executive. Of course the Navy, because of its obvious interests in the oceans, assumes a large part of this effort—in both the basic sciences and in investigations related directly to national defense.

Strengthening Basic Science

The Federal Government has in recent years financed an ever-increasing share of the Nation's research and development activity. During the current fiscal year, this share is estimated at about two-thirds, where ten years ago it was less than one-half. Expenditures amount to about $12.4 billion. Ten years ago, they were less than $3 billion.

The reason for this is well understood. Science and technology have become great, if not our greatest, national resources. The discoveries of science and their applications in technology have become so woven into the fabric of modern life that "our economy, our defense, our material welfare and comfort, and our physical well-being"* would soon disintegrate and vanish without them.

Federal support for basic research has also grown—to well over $1-1/2 billion this year, roughly 70 percent of the Nation's total.

*"A Great Age for Science," by Warren Weaver, in *Goals for Americans*, The American Assembly, Columbia Univ., 1960.

Much has been written about the need to maintain a vigorous and growing base of fundamental research, adequate to meet the suction for knowledge imposed upon it by the applied and developmental activities. Such a capability that ostensibly is free of concern for immediate use does not flourish without some measure of federal interest—and in fact, it has become a fact of history that governments become patrons of the sciences, as well as of the arts. But in contemporary terms this is not sheer altruism. We know from experience in war, in tough economic competition, and in man's fight for a life free of poverty and disability that research pays. It is the Federal Government that, in oceanography as in other fields, has strengthened basic research to provide the reservoir of intelligence needed to satisfy specific practical objectives. It must thus assume some responsibility for training and educating highly skilled manpower that it consumes, including the sponsorship of basic research undertaken by graduate students and their faculty advisors.

At the federal level, the National Science Foundation and the Office of Naval Research have formal commitments to see that basic work directed primarily towards the goals of the oceanographic scientists themselves is adequately supported. Large programs in the universities and various private laboratories and institutions, including those of industry, are supported by these agencies. But in addition, other agencies have found it necessary to support some basic research as well as applied in their own agencies or laboratories. The funds from all federal agencies which are directly applicable to the conduct of basic oceanographic science in 1963 amount to about 43 percent of the entire budget, making this goal of approximately equal importance to that of defense. During the next ten years, this figure is expected to rise to 57 percent.

Improving National Defense

It has become widely accepted that we, like the other major nations of the world, have a heavy stake in the preservation of peace. In the current world situation, military strength is a necessary element in our way of life. This must be a national capability so strong that the fact of its availability to the Free World is a deterrent to major infractions of the peace of the cold war.

Within our defense team the Navy's domain is the world ocean from its deepest depths through the air-sea interface and into skies above. During peacetime one of its most important missions is maintaining the freedom of the seas so that we and the other nations of the world may enjoy the advantages of water-borne commerce and transportation so vital to our growing economy. During wartime it must, in addition, deny this freedom to the enemy.

Freedom of the seas is a phrase and a concept which, through long usage, has been taken for granted and has, for many, come to have the inevitability of a law of nature. It should be remembered that it is instead a term for a situation which in the last analysis depends on the willingness and ability of those nations dedicated to it to resist the encroachments of those who would deny it to them. The United States Navy is the major Free World force upon which this freedom now depends. Since we are without question being faced by a serious challenge to our mastery of the oceans, the Navy is energetically pursuing a multitude of significant research and development programs to maintain our dominant posture at sea.

In oceanography the major objective, of course, is the greater understanding of the environment to enhance our capabilities in all forms of warfare. One example, and perhaps the one which most directly benefits from oceanography, is Anti-Submarine Warfare. Here, the sophistication and effectiveness of major improvements which have been made in weapons systems have been due not only to increased knowledge of the environment, but largely to advances in other areas of science and technology. Signal processing is a good example. The effective utilization of these systems, however, requires a broader and more detailed understanding of the environment, its properties and processes. Such understanding will, in addition, lead to new concepts of operations as well as new systems. It is for this main purpose that the Navy has undertaken a major oceanographic effort.

Let us briefly examine some of the properties of the environment and manner in which they influence naval planning. Sound is the only form of energy which propagates to any distance in the sea. Thus, much of the Navy's work centers on audibility problems. A submarine's audibility to underwater listening gear in various operating areas during the different seasons of the year depends not only on sound transmission conditions, which are affected by the temperature, salinity structure, depth, and reflectivity characteristics of the bottom, but also by the screening effect of noise created by breaking waves at the surface, the engines of other marine traffic, and the creaks, groans, snappings, and whistles emitted by a variety of sea creatures.

This is as true, of course, for enemy submarines as it is for our own. Everything we learn about how to hide our Polaris boats from enemy detection contributes, therefore, to our knowledge of how best to go about finding his.

When it is realized that sound not only travels five times as fast in water as it does in air, but for a given source intensity produces pressures which are some 60 times as great, it is not surprising that such ordinary sounds as the singing of rotating propellers and the swish of bubbles and eddies in the passage of a hull through the sea, all of which seem of comparatively short range to a listener on land, suddenly assume tremendous significance when the sound source is in water and the listener has "underwater ears."

Furthermore, the ocean is layered to an extent seldom realized in the atmosphere and the transmission of sound by "channels" in a fashion somewhat like the production of mirages in the air is a common occurrence in the sea. Submarines tens and even hundreds of miles away can sometimes be heard by listening equipment exploiting these sound conduits. Some layers, the most persistent, are very deep and can be utilized only by hydrophone arrays lowered down the sloping edges of islands or on the edges of the continental shelves to catch the deep sound transmission. Certain frequencies in the sound spectrum are more favored than others under some conditions. In general, the high frequencies are more easily attenuated and it is the very low frequencies which travel farthest. Since the size of the underwater ear must match the size of the wavelength being listened to, there is a complex design problem involved in fitting equipment to specific operational missions. That is, there is an important difference in systems optimally suited to an acoustic environment where treble notes with wavelengths of a few inches dominate, as compared to systems best suited to one where the bass notes which have wavelengths of many feet are most important.

The essential point is that increasing the range of detection of hostile submarines and the accuracy of target classification depends critically on oceanographic research. The Navy's Oceanographic Office, the Bureau of Ships, and the Office of Naval Research conduct or support research on various aspects of this problem, including the prediction of the key features of the "anti-submarine warfare environment" and how to exploit it operationally.

Almost every other Navy mission depends on similarly complex and critical relations between operations, technology, and environment. One reason aircraft carriers must be so large, for example, is to be sufficiently stable in a seaway that high-performance aircraft need not be exposed to dangerously large excursions of the flight deck as they approach the stern for a landing. Even high-speed destroyers and frigates have to slow down if waves are too high, and faster transits to distant operating areas can often be made by taking "the long way around" and avoiding the worst sea conditions enroute. Where timely arrival on the scene is important, such routing could spell the difference between failure and success. Weapons technology is also pressing against environmental constraints as torpedoes, missiles, and bombs have to push their way long distances at high speeds through the water or penetrate the interface between the sea and air without undue interference from waves, to find their optimal depth for detonation.

"Habitability" in the deep sea environment into which future submarines are expected to penetrate must be studied before the various compromises between size, structural strength, performance, and expense can be made intelligently. The ability of divers to work underwater with varying degrees of mechanical assistance is also of interest. The Bureau of Weapons and the Bureau of Medicine have important oceanographic programs in these areas.

The Navy's concern with these and many other facets of the ocean environment is reflected within its oceanographic budget. In Fiscal Year 1963, the Navy effort accounts for about 44 percent of the federal funding—$57 million of a total of $123 million. In addition to this work, the results of which may be applicable to many nonmilitary problems, the Navy allocates a substantial additional amount ($26 million in FY 1963) to projects which are classified or which are of a more direct and unique military nature. These latter projects are not included within the scope of the program embraced by this report but are detailed in TENOC—the Navy's comprehensive Ten-Year Plan in Oceanography.

Over the ten-year (1963-1972) period of this long-range plan, the Navy total is expected to be about $835 million, about 36 percent of the whole. Military oceanography not included in the plan amounts to $480 million additional.

These fiscal requirements would be greater still if interagency cooperation did not exist to make available to the Navy, information about planning of research on biological phenomenon by the Bureau of Commercial Fisheries and the Smithsonian Institution, and on the characteristics of the ocean bottom of importance to ASW, mine, and amphibious warfare, by the Coast and Geodetic Survey and the Geological Survey. The Army Corps of Engineers also contributes much information on harbor and channel regions in support of navigation and Mine Warfare operations, and the Atomic Energy Commission cooperates with all three services in atomic tests where underwater sound propagation, wave propagation, shock effects, etc., can all be studied.

—Continued on back cover (inside)

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A Host of
Scientific Interests are Outlined

There is an identity between the federal goal of strengthening oceanographic science and the scientist's goals in pursuing oceanographic knowledge for its own sake. Of course, it must be added that this identity is one of kind and not of degree. Some reasonable portion of the scientist's time and effort must be directed toward the numerous other and more practical goals of the government which is sponsoring his work. Nevertheless, it is important to understand what it is that interests the oceanographic scientist.

In oceanography, the National Academy of Sciences, through its Committee on Oceanography (NASCO), speaks for the scientific community as much as any committee can speak for people who are traditionally accustomed to speaking for themselves. The particular front-lines in oceanography as they existed four years ago which were singled out for special mention in NASCO's report of that year—"Oceanography 1960-1970, a Report of the National Academy of Sciences Committee on Oceanography, 1959."—are typified by a few of the questions posed in Volume II of this report, "Basic Research in Oceanography during the Next Ten Years." These fall into five main areas:

The History of the Oceans

"Why is the layer of unconsolidated sediments in the deep sea so thin, on the average only about 300 meters in thickness? . . . Why do we find fossils of Tertiary or Cretaceous age but none older? (That is, under about 100 million years.)

"In most cores taken in the Pacific and Atlantic there seems to be a sudden increase in radium content at an age level of about 200,000 years. What is the cause of this increase? . . .

"What is the history of the deep, narrow, almost sediment-free trenches that ring the Pacific Basin? . . . Why are these border features . . . apparently the loci of very low heat flow from the earth's interior?

"Existing abyssal plains are all adjusted to recent topography. Where are the ancient abyssal plains? . . .

"How have the broad swelling ridges that bisect the Atlantic and the South Pacific been formed? How old are they? Why are they the loci of very high heat flow from the earth's interior?

"Faults around the margins of the Pacific Basin appear to be right lateral as though the basin were rotating counterclockwise. Does submarine topography support this hypothesis? Are fracture zones the spokes of the wheel?

"Is the base of the crust a phase transition, or is there a real difference in chemical composition between crust and mantle?

"Are there pools or sheets of molten rock deep beneath the earth's crust associated with inland arcs, trenches and fracture zones? . . .

"What are the reasons for the large scale,remarkably regular magnetic topography of the deep sea floor off the west coast of North America? . . .

"What is the history of sea water? .. .

"How did the pattern of the major ocean currents during past times compare with that of today? . . ."

The Ways of Life in the Sea

"The fauna and bacterial flora of the great deeps provide unique opportunities for the general biologist. Nowhere else can he find organisms adapted to such high pressures and perpetual low temperatures. It also offers him intriguing questions:

"What are the enzyme systems that operate in these conditions? . . .

"What is the meaning—the function and history—of those strange structures, 'fishing rods' and 'lanterns', that characterize known inhabitants of the deeps? . . .

"Did an original ancient fauna adapt to and survive the severe drop from 12° to 2°C; or did this change bring widespread extinction and replacement?

"Recent years have brought discoveries of extremely ancient organisms;

"Under what conditions have these 'living fossils' survived? How can we account for the radically different evolutionary rates that we find in the sea? . . .

"The plankton is formed typically of small essentially floating creatures that we might expect to be uniformly dispersed, hence evenly distributed . . .

"How does the plankton, apparently helpless in the face of water movement, maintain discrete distributions? . . .

"What factors limit the distribution of communities, regulate their abundance and determine their internal structure?"

The Motion of the Waters

"Direct current measurements during the past year have shown that the east-west transport of water in the eastern tropical Pacific is probably at least three times that previously estimated. We may ask:

"How good are some of the other estimates of water transport? Just what, how big, and how complex is the circulation pattern of the oceans? This question leads in turn to others. What are the 'time constants' of the oceans? Why are some water masses but not others homogeneous over hundreds of thousands of square miles? Why is there the vast oxygen minimum beneath the thermocline in the tropical eastern Pacific and eastern Pacific and eastern Atlantic? What is the rate of mass exchange across the thermocline? Even more fundamentally, how are thermoclines formed and why do they persist?

"That the questions listed above remain unanswered reflects not only the lack of quantitative measurements of the motions of the ocean waters, but also the inadequacy of our thermodynamic and hydrodynamic models of the sea and the air. The two great earth fluids can be thought of as interlinked heat engines, and both theory and experiment need to be concentrated on the boundary between them . . .

"How are the waves formed, and how do they grow and decay? What is the partition of energy and momentum, transmitted by the wind to the sea, between waves, currents and turbulent motion?

"Waves beneath the sea surface, called internal waves, are far more mysterious than the waves at the surface.

"How are internal waves generated' Do they break near shore? Are they effective in mixing nearshore water? What is the role of internal waves of tidal period in tidal friction?"

Ocean-Atmosphere Relationships

"So intimately connected are the oceans and the atmosphere that basic research in one field must necessarily involve the other... Studies of these relationships may be highly fruitful in long-range weather forecasting.

"Less well-known and little understood are the long-term effects on climate caused by the ultimate stirring up of the deep ocean waters.

"Does the supply and coldness of the deep water vary at its source around Antarctica from year to year, or decade to decade? And if such variations occur, how long after and by what mechanism do they affect climate?

"In the deep waters of the sea, with their slow transport, we have a natural built-in lag which is a most promising beginning for the understanding and ultimate prediction of long-term climatic fluctuations."

Estuaries and Coastal Waters

"Men have lived since time immemorial near the seashore and have benefited from the natural resources of inshore waters. Yet little is known about basic processes at the margins of the sea. Consequently, coastal and estuarine waters are now claiming an increased share of attention from oceanographers.

"Some of the questions are:

"What are the mechanisms of sediment erosion, transportation, and deposition on the shelf and in the surf zone? . . .

"How are turbidity currents generated? Are they the primary means of transporting terrestrial material to deep water? At what speeds do they flow? . . .

"What is the flux of sediment from land to deep ocean? . . .

"What is the nature of the stress exerted by waves and currents on the bottom? . . .

"What world-wide changes in sea level have occurred in the past? What changes are in progress now, or are to be expected in the near future? . . .

In general, the same questions challenge oceanographic scientists today at just the time that technology and engineering have put the answers to many of them tantalizingly near his reach. The assessment of the National Academy of Sciences four years ago was "that both the quantity and quality of basic research in the marine sciences can and should be increased substantially during the years ahead." The challenge and promise are even greater now.

FOR WHOM IS THE LONG RANGE PLAN WRITTEN? For all persons interested in the nature, scope, and growth of oceanography in the United States. For the Congress, from which the appropriations for execution of the plan must come. And for members of the Executive Branch who must make decisions regarding the implementation of the proposals outlined. The plan is not a decision in itself; it is a basis for decision.

Research Approaches

Basic Science

If the present plans are carried out, the goal of strengthening oceanography as a science will receive a greatly increased fraction of federal support during the next ten years. Not only does the National Science Foundation intend to expand its present program almost fourfold during the decade, but the Office of Naval Research will approximately double its basic research support.

Project Mohole (NAVRESREV, *June 1963*) is not being included in the oceanographic budget, although many of its results will be as applicable to geological oceanography and to oceanographic engineering as to geology as a whole. It is expected that other geological drillings into ocean sediments will be undertaken in water of moderate depth. While all aspects of oceanographic science will be supported, physical and biological oceanography will receive the major share.

Special international programs are included in this category of goals. The International Indian Ocean Expedition (NAVRESREV, *October 1962*) a 32-nation, 40-ship effort begun in 1961 and expected to last until 1966 to which the U.S. is contributing 11 ships and about $24 million, and the International Cooperative Investigations of the Tropical Atlantic are examples. Basic research will be conducted principally in 35 private laboratories.

A considerable number of small laboratories and university departments also conduct basic oceanographic research, and many of these, such as the one at the Massachusetts Institute of Technology, are growing and new ones are expected to come into being. There are, in addition, approximately 12 large government laboratories and more than 20 small ones. Overall, the growth in the next decade is expected to be primarily in the number of large laboratories employing 30 or more scientists.

Private laboratories now operate a fleet of over 15 seagoing research ships and about 20 will be added to it by NSF and Navy funds in the next decade. The bathyscaph TRIESTE, presently the only operational deep research vehicle, is operated by the Navy. However, the Navy is sponsoring development of the ALVIN, a two-man submersible, capable of diving to 6000 feet, to be operated by the Woods Hole Oceanographic Institution. The ALUMINAUT, a three-man submersible, capable of 80-mile cruises at 15,000 to 18,000-foot depths developed and constructed with private funds, is being considered by the Navy for use in its research programs.

Defense

The oceanographic program of the Navy within the Plan in support of the national defense goal will total some $835 million over the ten-year period. This program can be categorized as follows:

RESEARCH

Included in this effort are the basic and applied research programs supported by ONR, BuShips, and BuWeps. These programs not only serve to advance the frontiers of oceanographic knowledge, but also serve to advance concepts in weapons development, detection devices, and naval armament systems in general by the consideration of favorable and limiting effects of environment. These research programs have applications to pro- and anti-submarine warfare, surface strike warfare, amphibious operations, Arctic operations, mine warfare, and in the general area of logistics support, including maintenance of hulls and submerged installations and transportation of men and material. A few highlighted research areas follow:

USW Research

The Navy's primary concern in oceanography relates to undersea warfare. At least six Navy laboratories currently participate in an intensive campaign of oceanographic research that includes investigations of the shape and nature of the sea floor, description of the activity and constituency of the sea itself, and the quantification of the interactions between the ocean and atmosphere related to underwater acoustics and the parameters of temperature, salinity, sea surface phenomena, etc.

Other Physical Properties

Many other physical properties and phenomena, such as surface and internal waves, tides, currents and turbulence, infrared and electromagnetic properties, radioactivity, optical properties, and many individual bottom properties, have technical and design implications. Practically every bureau laboratory active in Navy oceanography participates in one or another aspect of this program, which is coordinated by the Office of Naval Research.

Marine Biology

Marine creatures interfere with underwater acoustic systems, influence mines and mine countermeasures, damage structures, luminesce, are poisonous, venomous or toxic, and provide clues about the presence of underwater targets. Again the Office of Naval Research coordinates this research program, which includes participation of five Navy laboratories.

SHIPS

The second major category of Navy funding concerns construction of oceanographic ships. It is divided nearly evenly between the direct support of Navy projects and the support of interagency or privately initiated projects from which the Navy is expected to benefit in common with other participants.

MILITARY SURVEYS

The Naval Oceanographic Office carries out a program of military surveys. In contrast to the national Ocean Survey Program, which has as its objective a general strengthening of knowledge of the oceans, the military survey program is focused specifically on the Navy's operational requirements. These surveys are designed either as mapping and charting expeditions for strategic areas or to provide environmental information requisite to design, installation and operation of anti-submarine warfare systems. A fleet of eight ships and a current annual budget of about $11 million supports this program.

During the coming decade 13 ships (of which seven will replace existing hulls) will be added.

Although data are collected for classified military operations, a very large fraction resulting from those surveys is publicly available through the National Oceanographic Data Center.

INSTRUMENTATION AND FACILITIES

Seven percent of the Navy's projected budget ($60 million) is allocated to development and procurement of oceanographic instrumentation. Featured in development programs will be sensing-recording-processing systems for rapid and accurate data acquisition and treatment. Part of the Oceanographic Office instrumentation budget supports the developmental effort at the Navy's Oceanographic Instrumentation Center. The remaining one percent of the budget will go toward the building of new facilities, both privately operated and military.

DEEP SUBMERGENCE VEHICLES

While recognizing the sea, from surface to ocean floor, is the available arena for naval warfare, most activities have been carried out at or near the surface. Combat submarines are being designed for deeper operation, but by and large the only manned vehicle for full vertical access to the ocean has been the TRIESTE. However, it has only a two-mile horizontal range. A far more ambitious study of Navy requirements is now being undertaken in relation to deep operations, including salvage.

The Navy is considering three types of vehicles, but no explicit funding is provided in this plan. The first type, designed for cruising along the continental shelf and work on bottomed equipment along the continental slope, is intended to dive to approximately 5000 feet, and cruise at slow speeds for 8 to 10 hours. Four of these are considered required early in the decade with six more later.

A second type is intended to operate to 15,000 - 20,000 feet and consequently to be able to reach bottom across 90 percent of the ocean floor. It should be able to cruise at slow speeds for as much as a day. Two of these are to be required for research prior to 1970 with two more thereafter.

The third type is intended for deep trench investigations and should go to 36,000 feet. It will probably have a limited ability to cruise at depth. A total of two of these is desired, one prior to 1970.

TENOC

The Navy first developed a long-range plan in oceanography in 1959, referred to as TENOC ("Ten Years in Oceanography"). Periodically updated, TENOC reflects advances in both science and operational requirements, with a balanced program organized in ten areas of effort. Of the Navy's total oceanographic budget of $1315 million, only $835 million, or about two-thirds, is included within the National Oceanographic Program as categorized by the ICO. Some additional $480 million is devoted to applied research and development of a more direct military character.

The research to be accomplished by the more immediately defense-oriented portion of this plan is in four major subject areas including acoustics, magnetics and gravity, Arctic operations, and environmental forecasting.

Acoustics Research

The Bureau of Ships coordinates the acoustics program, which is directed toward understanding, predicting, and exploiting acoustic propagation phenomena. This is concentrated in nine Navy laboratories supplemented by ONR-supported work in eight private and university laboratories. Many industrial organizations under contract to the Navy for sonar, torpedo, and other ASW/USW equipment also do work in oceanographic acoustics in connection with their development programs.

Magnetics and Gravity Research

Programs to examine and exploit geomagnetic and gravimetric phenomena are coordinated by the Bureau of Naval Weapons. Four naval laboratories and four private oceanographic laboratories participate in this program related to submarine navigation, missile guidance and ballistics, submarine detection, and mine countermeasures operations.

Arctic Research

Operations in the Arctic now require knowledge of under-ice as well as ice-edge phenomena. The Office of Naval Research coordinates work done principally in four Navy laboratories and the Arctic Research Laboratory of the University of Alaska on the Arctic oceanic environment.

Environmental Forecasting

The oceanographic forecasting program, though planned to absorb only one percent of the Navy's oceanographic budget during the next decade, deserves special mention. This figure includes only the research and development aspects of programs, most of whose cost is to be borne by fleet operating and maintenance budgets. They are intended to improve the capability to forecast the ASW environment, as well as to predict the consequences of harbor flushing and disposal of nuclear products, etc. Many of these forecasting programs will emerge from the research or experimental stage and enter the operational stage in the coming decade.

New Instruments Will Be Perfected

The instrumentation requirements for the next decade of oceanographic research are formidable. At the same time, technology and engineering promise at last to provide much that has long been lacking.

It has been difficult to keep oceanographic instrumentation in step with technological advances in other areas for two major reasons. One is that the need for high precision for instruments used in a harsh environment places extreme demands on a designer's skill. Temperatures must be correct to the nearest .01 degree Celsius and salinity to the nearest two parts in a hundred thousand over pressure ranges from one to perhaps 1000 atmospheres if density determinations made from them are to be correct to the nearest part in a million, as is required for the study of some physical processes. Other instruments, such as thermal probes to measure heat flow through the sediments at the bottom, depth recorders, sonic probes, plankton collectors, and audio-visual devices for fish observations and surveys and the like, have similar extreme demands on their quality.

The second reason for the archaic state of oceanographic instrumentation is that this demand for high quality is coupled with little demand for quantity. As a consequence, there has been little incentive for heavy investment in their development by those industries most competent to advance the state-of-the-art. As a result, most instruments were originally designed, built, and even manufactured in such quantity as needed by versatile oceanographers themselves. The numerous Nansen devices, still in use after 50 years, the bathythermograph, and the Ekman current meter, are all examples, excellent of their kind yet hardly to be compared in engineering sophistication with recent products of the space industry. Telemetering, data processing, communications, and other back-up systems could all be improved, as could almost every device now in use.

Development during these next ten years is expected to emphasize increased speed and efficiency of standard measurements rather than the creation of devices for obtaining new types of information. In addition to automating many of the shipboard procedures now carried out tediously by hand, the Navy, Coast and Geodetic Survey, Bureau of Commercial Fisheries, Coast Guard, and the Weather Bureau are seeking automated fixed stations for sensing and transmitting oceanographic data remotely on a routine basis.

Instrumentation for marine biology has lagged even farther behind than that for other aspects of marine science, and particular effort will be made to develop more satisfactory plankton recorders, sampling gear, and underwater camera and television equipment. A so-called "parameter follower" is being sought by several agencies. This device, intended to be towed or self-propelled, would sense a given concentration of one parameter and remain within it while recording variations in others. It is expected to be particularly helpful in fish migration studies, simulating some of the important behavior patterns of migrating fish.

Moored buoys with strings of current meters for obtaining extended records at a given point have been in use for several years. The present models require retrieval in order to obtain the data, and this has proved both time consuming and unreliable. Developing moored buoy systems to accommodate a variety of instruments and telemeter data first to the surface and then to shore stations, aircraft, or satellites has therefore been an attractive possibility. The Office of Naval Research has been conducting a systems study program for the last two years on various configurations and alternatives.

These studies have determined an optimum size and configuration for a system capable of telemetering data at the rate of 300 bits per minute on an intermittent schedule with high reliability over a distance of 2500 miles while remaining unattended for up to a year. Prototypes are under construction together with a shore command station, mooring techniques are being developed, and oceanographic sensors are being designed. A complete buoy system should be available at the end of about two more years. The program is being guided by an advisory committee of the ICO consisting of research oceanographers as well as experts in buoy technology and representing private institutions as well as the Navy. This development program is estimated at about $3 million.

Other smaller buoys for specialized purposes have been developed with ONR support at both Scripps Institution of Oceanography and the Woods Hole Oceanographic Institution for a number of years and this work will continue.

Many agencies are contemplating plans based on the use of anchored buoy stations in rather large networks within the next few years. Before these plans are executed, three important interim steps should be taken. First, the development program should be carried to the point where sensors are reliably capable of long unattended operation and the buoy can be counted on to hold its moorings and transmit significant amounts of information over the required distances. No buoys have these characteristics at present and much more expensive development is required. Second, once such buoys are available, none should be installed until the time space-data sampling requirements are thoroughly worked out. These requirements depend on the scientific question being asked, the process to be studied, and the scale characteristics of other processes also capable of producing sensor responses appearing as "noise" in the data record. The noise must not obscure the signal. Finally, efforts under way at tht international level to establish legal and operational conventions must be completed.

The Navy expects to carry three-fifths of the total of $103 million planned for the instrumentation program, reflecting a massive effort to expedite solutions of problems of packaging sensing-recording-processing systems, to perfect deep diving exploration vehicles, and to overcome sound attenuation. The remaining two-fifths will be fairly evenly divided among the Bureau of Commercial Fisheries, Geological Survey, Bureau of Mines, Coast Guard, Weather Bureau, and the Coast and Geodetic Survey. Particular efforts are therefore being made to assure thorough exchange of information among the agencies concerned by the establishment of a central file of instrumentation data at the National Oceanographic Data Center, the publication of an encyclopedia of oceanographic instruments, and the joint agency use of the Navy's Oceanographic Instrumentation Center at the Navy Yard Annex in Washington, D.C.

The pursuit of oceanography toward the many non-defense goals outlined in the complete ICO plan is dependent on the freedom of the seas which the Navy provides, and which the Navy's oceanographic program sustains.

Scientific Manpower Will be Augmented

A capability on which all else depends is an adequate corps of trained, imaginative, and skillful scientists. No other problem in basic oceanography currently warrants greater attention than the manpower problem, in spite of the fact that the ranks of oceanographers are expected to continue to grow at a rate moderately in excess of the national average for scientists as a whole. This projected growth in oceanography of about ten percent where the national increase in all types of scientists has averaged about seven percent is the basis for the programs now planned in pursuit of the national goals in oceanography. Meeting these requirements is expected to result from the continued transfer of scientists from other basic fields such as physics, geology, chemistry, biology, mathematics, and engineering since fewer than 100 degrees in oceanography are granted each year. The greatest educational shortages are projected to lie in the areas of physical and meteorological oceanography, although systematic biologists, marine geophysicists, and geochemists are also scarce. Other types of marine biologists and geologists are currently being trained at an adequate rate. Two attacks on the problem currently being mounted involve motivation at lower academic levels and increased application of training grants.

In one respect, the large number of transfers from other fields is desirable. It provides a cross-fertilization of ideas which is particularly valuable in oceanography where many of the processes of greatest interest are best dealt with from a multidisciplinary point of view. As oceanographic frontiers are pushed back, more and more specialized knowledge in an increasing variety of technologies and fields of knowledge is required to help solve the novel problems which keep turning up, and to devise new "tactics" to surmount unprecedented difficulties.

On the other hand, the "strategic" approach to oceanographic knowledge to assure its advance over a broad front can hardly be certain without the creative activity of a large number of people broadly trained and widely experienced in oceanography itself.

In the light of this situation, the direct support provided by the National Science Foundation, and the Departments of Interior and HEW for fellowships and training grants in oceanography might seem small, especially since the ten-year projection shows little increase over the period. However, the problem is strongly cyclic and self-limiting. University departments have more than their share of trouble attracting oceanographers already in short supply anyway and temperamentally more interested in research, particularly seagoing research, than they are in teaching. They tend to go to the great oceanographic institutions such as Woods Hole and Scripps where research receives major emphasis. It is a rare university which can combine both types of facilities. They might produce still more if they retained more of their graduates in teaching positions rather than losing them to research, but this would produce an even greater deficit of research oceanographers during the interim. The best way to prime the educational pump in oceanography is one of the subjects greatly in need of study during the coming years and is a high priority item for one of the panels of the Interagency Committee on Oceanography.

Surveys and Services to Assume Important New Roles

Some programs and activities in oceanography are undertaken to meet needs felt more or less strongly by each group within the oceanographic community but which are beyond the capacity of each to meet separately or of any to provide for all. Among these are broad area surveys, the maintenance of a complete library of oceanographic data, the testing and calibration of a variety of instruments, including novel ones, and forecasting oceanic conditions of both research and operational interest.

The first two of these are present realities as are ice and wave forecasting. The Ocean Survey Program ultimately may be a part of an international effort. It has already begun in a small way with the closely controlled underway lines and the network of oceanographic stations set up in the North Pacific by the Coast and Geodetic Survey's PIONEER in 1961.

The second service type activity is the National Oceanographic Data Center (NODC) which was established two years ago to assemble, process, store, and disseminate to interested users all oceanographic data collected anywhere. Both these programs were endorsed and implemented through the Interagency Committee on Oceanography.

The Navy has just established its own Oceanographic Instrumentation Center and steps are being taken to make this available to users on a national basis. The Navy's ASWEPS (Anti-Submarine Warfare Environmental Prediction System) is expected to become operational around 1965. It may also provide some nonmilitary applications.

The Ocean Survey Plan

Both the scientific community, through the National Academy of Sciences Committee on Oceanography, and various federal agencies have expressed the need for systematic mapping of the major properties of the oceans, the basins which contain them, the sediments which lie under them, the forces such as gravity and magnetism which permeate them, and the life which they contain. Such mapping can, of course, serve a variety of goals, providing tools for use in military and economic welfare, as well as in scientific oceanography.

The ship requirements for an ocean survey program cannot be determined exactly, since the desired rate of progress cannot be established except on subjective and intuitive grounds. Furthermore, the actual rate of progress which various survey ships will demonstrate, once assigned, cannot be precisely estimated. Presumably much can be done to make present operations more efficient if the ship is designed and equipped for participation in a coordinated program than would be the case if its survey work were done in isolation. Finally, the value of information collected from survey lines taken at close intervals, say ten miles apart, as compared to that which would result from lines 20 or even more miles apart must be weighed against the differences in cost or time associated with each. It is possible that buoy developments may proceed rapidly enough to replace some ship survey effort late in the time period.

Both the need and the magnitude of the job will never be greater than at present, however, and it is the present intention to proceed with an orderly survey program as rapidly as funds and personnel will allow. The Coast and Geodetic Survey, acting as agent for the ICO, has awarded a contract for a major planning study of optimal survey systems and their deployment. As estimated now but subject to reconfirmation as plans mature, the next decade should see 24 new survey ships—16 built by the Navy to serve both in the ocean survey program (5) and for special military surveys (11) and eight by the Coast and Geodetic Survey (primarily for the ocean survey program). These plans will be responsive to new developments in instruments, particularly in buoys which may multiply the unit effectiveness and permit much more rapid progress, and to progress in cooperative plans with other nations. The present estimate is that the ultimate share of the United States in the world ocean survey will be approximately 30 percent (to be prosecuted mainly by the Naval Oceanographic Office and Coast and Geodetic Survey with assistance from other agencies).

The program planned here is expected to run about $260 million over the decade.

The National Oceanographic Data Center

The need for a centralized repository for the Nation's oceanographic data has been recognized for many years. The federal agencies through the Interagency Committee on Oceanography recommended a jointly sponsored center to the Federal Council for Science and Technology, and this plan was approved in June of 1960. In November, the NODC was established as an administrative component of the Navy's Hydrographic (now Oceanographic) Office, and began work under the policy guidance of an interagency Advisory Board representing the six supporting agencies—Navy, Coast and Geodetic Survey, Bureau of Commercial Fisheries, the National Science Foundation, the Atomic Energy Commission, and the Weather Bureau—and the National Academy of Sciences.

NODC functions as a service activity for all segments of the Nation's scientific community with respect to marine environmental data and information requirements. It also makes these data accessible to the general public free of charge or provides copies at cost.

In performing this function NODC must, of course, receive, compile, process, and preserve oceanographic data in a form permitting rapid retrieval. It thus establishes procedures for insuring that the accuracy and general quality of the data meet the criteria established by an Advisory Board. Finally, it prepares data summaries, tabulations, and atlases showing annual, seasonal, and monthly oceanographic conditions. The technical problems in carrying out these functions adequately are formidable, and all the resources of modern data handling technology as well as an informed understanding of the oceanographic community's needs are being brought to bear.

Housed in downtown Washington in the former Naval Weapons Plant, the National Oceanographic Data Center has a staff of approximately 80. Its budget during the next ten years is expected to total approximately $15 million. About half of this expense is presently borne by the Navy, and most of the remaining half is evenly divided among the Coast and Geodetic Survey, the National Science Foundation, and the Bureau of Commercial Fisheries. The Weather Bureau, the Atomic Energy Commission, the Coast Guard, the Geological Survey, and the Department of Health, Education, and Welfare each contribute about two percent.

The Navy's Oceanographic Instrumentation Center

Although the Oceanographic Instrumentation Center is a Navy activity, it cooperates with other government agencies, private industry, and the academic community to bring about improvements and refinements in instrumentation, serving their needs to the extent possible. It is an attempt on the part of the largest user of oceanographic instruments to assure that the data it obtains about the oceans is precise and accurate.

After a slow evolution in the 1950's, the Navy's Oceanographic Office Instrumentation Division blossomed into the present Center in November 1962. It has a staff of about 100 engineers, scientists, technicians, and supporting personnel. It contains engineering facilities for laboratory and contractual development, test, and evaluation, and the maintenance of instruments. It is developing such new instrumentation as improved electronic bathythermographs, shipboard wave recorders, a shipboard survey system, submerged buoy systems, and sound velocimeters.

Its test equipment is extensive and modern, including pressure test vessels, shock and vibration test equipment, tensile test facilities, pressure and temperature tanks, reversing thermometer calibration equipment, a 60-foot clear-water instrument test tower, and a small craft for environment testing in local waters. It intends to provide engineering advice and assistance to agencies and activities on oceanographic instrumentation matters, and to serve as a clearing house for information on the oceanographic instrumentation development program.

Its budget, which is borne by the Navy, is expected to total approximately $30 million over a ten-year period.

Oceanographic Forecasting Service

The Navy has two environment and wave forecasting programs which could conceivably lead to developments of interest to nonmilitary users. They are instrumented to handle on a fully automatic basis incoming bathythermograph and sea surface temperature observations and to issue charts of the depth of the upper isothermal layer and the surface temperature variation. The major limitation is the crudeness of the inputs of the present data, which cause the outputs to be relatively unsophisticated, but improvements are continuing and they provide valuable supplements to the ASWEPS program, scheduled to become fully operational sometime after 1965. Standing for Anti-Submarine Warfare Environmental Prediction System, ASWEPS is intended to provide forecasts of a large variety of oceanographic variables of particular significance to the operating forces. These variables will describe in considerable detail the ocean environment in at least the upper layers. It is hoped that enough information about the sensors, installations, prediction techniques, data processing know-how, and various automation methods can be made available for the development of a

—Continued on back cover (inside)

International Cooperation

Many of the considerations which have led the United States to its recently intensified interest in the sea have similarly motivated other nations as well, and in many cases for much longer. As each has sought to learn more about the sea, it has quickly come to realize that the sea is very large and its own unaided efforts very small. As far back as 1899, a conviction that effective exploration of the sea based on sound scientific principles demanded international cooperation led to the formation of the International Council for the Exploration of the Sea (ICES). Established by eight nations (Denmark, Finland, Germany, Great Britain, Netherlands, Norway, Russia, and Sweden) to conduct a joint exploration of the North Atlantic, the North Sea, the Baltic Sea, and the adjacent waters, the ICES raised and tentatively settled such important issues as the standardizing of techniques and instruments and the exchange of data.

The International Geophysical Year is the most recent major manifestation of the tradition of international cooperation in scientific exploration of the oceans. It was both the result and the cause of the formation of a great number of international organizations for scientific cooperation, both governmental and private. UNESCO, which had sponsored the development of many intergovernmental associations, established the Intergovernmental Oceanographic Commission (IOC), in 1960, with a membership list of 40 countries, including the United States. Two other United Nations bodies, the Food and Agriculture Organization (FAO) and the World Meteorological Organization (WMO), and one nongovernmental organization, the Scientific Committee on Oceanographic Research (SCOR) of the International Council of Scientific Unions, were the three most closely identified with the IOC's purpose and have maintained close working relationships with it ever since.

The IOC assumed coordinating responsibility for the International Indian Ocean Expedition, originally organized and coordinated by SCOR, with SCOR continuing to act in an advisory capacity. It agreed to undertake the International Cooperative Investigations of the Tropical Atlantic Ocean, as suggested by the United States, and is actively making plans to start two closely related projects, both suggested by the USSR. These are a standard section program to study time changes in characteristics of the oceans, and a North Atlantic expedition for studying fields of currents by dynamic techniques. In addition, it concerns itself with the perennial questions of standardization, intercalibration, and the exchange of data as well as some of the more particularly modern problems, such as the legal status of fixed buoys, frequency allocation for telemetering and other communications, and the availability of new aids to navigation such as Loran C and the Transit satellite system under development by the United States.

Not the least important aspect of such activities is the opportunity they provide for scientists and technicians from nations with research ships and facilities of their own to participate and to further their own training while contributing to the collection of knowledge which is itself of mutual benefit.

The United States, with 11 ships already committed to the Indian Ocean Expedition and five more to the Tropical Atlantic Expedition, plans to put between

$70 million and $90 million into such cooperative programs during the coming decade. The Interagency Committee on Oceanography, at the request of the State Department, is the United States point of contact for activities related to the IOC. United States participation in these programs is based on requirements which we would otherwise have to pursue alone. By joining our efforts with those of other nations with similar needs, we not only foster friendships and common interests among the collaborators, but greatly increase the scientific benefit which we, like the other participants, realize for the effort which each has expended.

It is not possible to determine with any great accuracy the present size and scope of specific foreign oceanographic programs. Like ours they are changing in both respects. Up-to-date figures are not always available even when free access to official information is granted, and in the case of the USSR, the program of perhaps greatest size and interest, this access is not free. Also, definitions are not uniform. For example, foreign programs show about three technicians for every scientist where the U.S. shows only one. Perhaps a third or more of the foreign technicians might be classed equally well as scientists, effectively doubling the numbers given in the sections which follow. What is known, however, indicates that the United States, the USSR, Japan, the United Kingdom, and Canada, lead the other nations of the world in the extent and quality of their programs.

It has been the declared intention of the President and the Congress that the U.S. should maintain world leadership in this field of science. The following discussion should help illuminate this country's present position in terms of size, scope, and quality. In a field where so much opportunity exists for new discoveries, there is never room for complacency.

USSR

The USSR is reputed to have more than 70 ships available for oceanographic research, though undoubtedly many of these do double duty as mother ships for fishing fleets or act as icebreakers and as naval escorts or supply ships. Their fishing fleet of over 3000 vessels, deployed to fishing grounds all over the world, presumably contributes to the collection of oceanographic data also. It is also likely that many of their merchant fleet, now consisting of more than 1000 ships and growing rapidly, take observations of near-surface oceanographic conditions as well as reporting meteorological conditions into the world synoptic weather net.

Their best known research ships are the MIKHAIL LOMONOSOV, built in 1957 of about 5960 displacement tons with some 16 oceanographic laboratories and space for about 75 scientists on board; the VITIAZ, similar in size though built in 1939; the SVERYANKA, a research submarine; and the 12,000-ton OB, built in 1953. In addition to these floating laboratories, two other large ships of about 4600 tons, the PETR LEBEDEV AND THE SERGEY VAVILOV, were refitted in 1960 while the SEVASTOPOL, a 2500 tonner, has been in the research fleet since 1951. The ZARYA, a small sailing ship, is the world's only nonmagnetic research vessel. The exact size of their professional oceanographic scientific staff is not known but is estimated at about 500 - 700 scientists and about 1600 technicians, thus considerably smaller than that of the U.S. Their work is of broad scope and generally high quality. It is of interest to note that the Soviet Interdepartmental Coordination Scientific Council on the study of the oceans and seas is somewhat similar in concept to the ICO.

Japan

The Japanese effort in oceanography is now estimated to have passed that of Great Britain and to rank behind only those of the U.S. and the USSR. It has traditionally been concerned with the problems of fisheries, shipping, and protection against marine catastrophes, such as tsunamis, storm surges, and typhoons. These preoccupations, natural to an island nation with a dense population, little arable land, and modest mineral resources, have resulted in a strong emphasis on applied research and a program conducted almost entirely within the governmental meteorological, fisheries, and hydrographic agencies. Though some 16 or so universities have facilities for oceanographic and fisheries studies, their role in Japanese oceanography has been primarily educational. In addition to excellent fisheries research, Japanese oceanography has long been considered to excel in air-sea interaction studies, tsunami prediction, sea water chemistry, and problems of the Kuroshio current dynamics.

Recent developments indicate a trend toward more basic research and broader scope. A new Oceanographic Institute devoted to basic research is planned for Tokyo University, and two research vessels of about 300 tons are to be built for its use. Greater emphasis on physical, chemical, and geological oceanography can be expected in the future.

This broadening interest is already manifest in the recently initiated program of "Japanese Expeditions to the Deep Sea," a continuing series, four of which have already taken place.

Japan's traditional willingness to participate in international surveys and expeditions, as well as her growing interest in deep sea oceanography, is shown by the assignment of five of her approximately 24 survey and fisheries research vessels to the International Indian Ocean Expedition. This fleet is comparatively new, three-quarters of it being less than 12 years old. It is also very capable, with six of the ships exceeding 1000 tons and only two under 200 tons in size.

The Oceanographic Society of Japan includes more than 500 members, and the work force is estimated at 200 - 225 professionals with about 600 technicians. About 30 - 35 students graduate with bachelor's degrees in oceanography each year, but only four of five doctorates are conferred. The annual oceanographic budget is estimated at about $10 - $12 million.

United Kingdom

It was the British "Challenger" Expedition in 1873-1876 which first opened the oceans of the world to modern science, and the British have maintained a leading place in world oceanography ever since.

British oceanography centers in the work of the National Institute of Oceanography, generally considered one of the outstanding oceanographic institutions in the world. It was founded in 1949, in Surrey, to centralize the work of three older establishments—the Discovery Committee, the Oceanographic

Branch of the Admiralty, and the Underwater Sound Establishment at Teddington.

The work at NIO emphasizes physical oceanography, including wave studies and current measurements, but its program also includes some marine chemistry, sea-floor geology, geophysics, and marine biology. Its staff is led by about 20 senior scientists, and its major oceanographic vessel is the new DISCOVERY. Its operating budget has risen from about $3/4 million in the middle of the last decade to about $1.8 million today.

The Ministry of Agriculture and Fisheries conducts a program of applied oceanography at its laboratory in Lowestoft, operating the research vessel ERNEST HOLT. The Fisheries Biology for Scotland has a laboratory in Aberdeen, and the Marine Biological Association has a laboratory in Plymouth.

Education and research in physical oceanography is conducted at the Department of Oceanography at Liverpool, where the University also maintains the famous Tidal Observatory. The Department of Geodesy and Geophysics at Cambridge conducts ocean-floor studies, and some eight additional universities have recently initiated programs also in marine geology. The British Museum and the British Petroleum Company also have programs in geological oceanography.

Large-scale hydrographic survey work is conducted on a world-wide basis by the Admiralty with a survey fleet of about ten vessels.

There are about 300 professional oceanographers in the United Kingdom supported by about 900 technicians. Some 40 - 45 bachelor's degrees in oceanography are granted each year, but only 5 - 6 doctorates. The ocean-going research fleet includes about 16 vessels, and the annual budget is estimated at about $8 - $10 million.

Canada

Canada conducts a large, well-rounded program in all phases of oceanography but with special application to the Arctic and sub-Arctic. A central Canadian Committee on Oceanography, representing both universities and government agencies, establishes basic policy and coordinates the research program through four working groups, each concerned with a different geographical area.

There are approximately 170 professional oceanographers and 500 technicians working in a total of about 14 laboratories. The Canadian research fleet consists of 17 vessels, including several refitted icebreakers, and ships normally operated for the Fisheries Research Board. The annual budget is estimated at about $58 million.

Observers for the Interagency Committee on Oceanography are--

RAGNAR ROLLEFSON, Director, Office of International Scientific Affairs, Department of State
ATHELSTAN SPILHAUS, Chairman, Committee on Oceanography, NAS
E. L. DILLON, Budget Examiner, Bureau of the Budget
EDWARD WENK, JR., Technical Assistant to the Director, Office of Science and Technology

For list of members, see bottom of Page 3

On The Naval Research Reserve

The Air Force Academy chapel

Reservists discuss proceedings and study unusual architecture.

First Research Reserve Seminar on Aerophysics

The First Research Reserve Seminar on Aerophysics was held last month at Denver, Colorado, on the campus of the University of Denver. The meeting, which was cosponsored by the Office of Naval Research and the University of Denver, convened on August 5 for two weeks of lectures, discussions, and tours. Fifty-nine Naval officers, as well as eleven Army and five Air Force reservists, took advantage of this opportunity to learn of latest developments in the rapidly changing field of Aerophysics.

The Aerophysics Seminar was a composite effort on the part of the three Naval Research Reserve Companies in Colorado—NRRC 9-12, Fort Collins; NRRC 9-17, Boulder; and NRRC 9-21, Denver. LCDR Harold E. Bluebaugh, USNR, a member of NRRC 9-21, was primarily responsible for arrangements for the seminar. He was given able assistance by LCDR Robert D. La Rue, USNR, NRRC 9-12; LT Martin T. Decker, USNR, Commanding Officer, NRRC 9-17; and numerous members of the three Naval Research Reserve Companies.

The opening session of the seminar was chaired by CDR O. D. Hughes, USNR, of the Office of Naval Research Branch Office, Chicago. Dr. Shirley A. Johnson, Jr., Director of Denver Research Institute, welcomed the conferees on behalf of the University, and discussed, briefly, the interesting and diverse work in progress at the Denver Research Institute. Following him was CAPT R. C. Gossom, USNR, Deputy Chief of Staff for Naval Reserve, Ninth Naval District, who welcomed the participants to the Naval District.

A distinguished veteran of the Navy's program in aerospace research, RADM L. D. Coates, USN, Chief of Naval Research, addressed the seminar on its opening day at a luncheon. He gave a most interesting and informative review of naval aerospace research efforts.

At ensuing sessions the group was addressed by an imposing succession of authorities in a broad variety of technologies relating to aerophysical research. Much of the program dealt with physical phenomena exhibited by the earth's atmosphere, inner space, and the sun, and with the means by which these phenomena are studied. The manned space program and the technologies required to achieve extended manned space flights received excellent coverage. Advanced weapons concepts, communications, and engineering problems in space research were also discussed in this most informative series of lectures.

Field trips to many of the interesting facilities in the region were interspersed with the lecture program throughout the two-week seminar. In the Colorado Springs area, the group toured the facilities of the U.S. Air Force Academy, and attended a special briefing at the North American Air Defense Command Headquarters. Those research-oriented members of the group were particularly interested in the National Bureau of Standards Laboratory and the facilities of the University of Colorado. Both institutions were visited during an all day field trip to Boulder, Colorado. Visits were also made to a Titan I silo of the 451st Strategic Missile Wing at Lowery Air Force Base, and to the laboratories of Colorado State University at Fort Collins.

A formal banquet, held at the Lowery Air Force Base Officer's Club, climaxed the two-week program. On this occasion, Dr. Philip D. Thompson, Associate Director of the National Center for Aerophysic Research, discussed the scientific program and plans at that institution.

Just as the beautiful campus of the University of Denver provided an atmosphere conducive to the high-level objectives of the seminar, so the delightful Rocky Mountain setting provided ideal facilities and setting for leisure hours. The conferees, many accompanied by their families, enjoyed the mountain scenery and the many cultural attractions available in the area.

Reservists who attended this First Reserve Research Seminar on Aerophysics found the program to be current, comprehensive, and challenging. As a result of the interest evidenced in this program, plans are now being made for a second seminar on the same subject.

—LT W. V. Sample, USNR, NRRC 9-21

Biological Defense Seminar

The Second Research Reserve Seminar on Biological Defense sponsored jointly by the Office of Naval Research and the U.S. Army Biological Laboratories took place at Fort Detrick, Frederick, Maryland, August 11-24. The tri-service program was under the direction of members of Naval Reserve Research Company 5-3, located at Fort Detrick, and commanded by CDR Robert F. Jaeger, USNR. Dr. Henry T. Eigelsbach, (CDR, MSC, USNR), was the seminar chairman. He stated that the goal of NRRC 5-3 was to make the seminar a beneficial training experience for the reservists. Sixty-one reservists (34 Navy, one Marine, 20 Army and 6 Air Force officers) from coast to coast attended the two-week session. When they arrived in the city of Frederick, they observed "Research Reserve Officers, Welcome to Frederick" displayed in letters one and one half feet high. At the order of the Commanding Officer of Fort Detrick, the main entrance was impressively decorated with flags.

The seminar objective was to acquaint the reservists with the capabilities, limitations, and problems concerning biological weapons and defense. Subject matter presented was considered from both scientific and military points of view.

A demonstration of assessment of viable bacterial populations is presented to 1st LT W. C. Hausman, USAR, 2nd LT T. B. Gortemoller, USAFR, CDR R. F. Jaeger, USNR (Commanding Officer, NRRC 5-3), and CDR J. A. Alford, USNR, by Dr. F. A. Leonard, Chief of the Medical Bacteriology Division.

Col. Carl Casto, USA, Commanding Officer, Fort Detrick, conducts RADM L. D. Coates, USN, Chief of Naval Research, and BGen. F. J. Delmore, USA, Commanding General, Edgewood Arsenal, on a tour of the ultramodern biomathematics building.

LT J. D. Sink, USNR, Maj. J. A. Cameron, USMCR, and Capt. G. P. Psihas, USAR, are given information on the use of the monkey as an experimental animal by Dr. Melvin Rabstein, Chief of the Fort Detrick Animal Farm.

COL Carl S. Casto, USA, Commanding Officer, U.S. Army Biological Laboratories, opened the seminar with a warm welcome. In his remarks he stated, "Over the years we have enjoyed the interest and received the support of the Navy in our research programs. We at Detrick welcome this opportunity to discuss our problems, inform you of our accomplishments, and arrange visits to our laboratories. In this manner it is our hope that you will see the welding of the many scientific disciplines into an important effort in the defense of our nation." Other "welcome aboard" messages were given by Dr. Riley D. Housewright (CDR, MSC, USNR), Scientific Director of Bio Labs; COL Dan Crozier, MC, USA, Commanding Officer, U.S. Army Medical Unit; and CDR Leon P. Eisman, USN, Commanding Officer, U.S. Navy Unit, attached to Fort Detrick.

In his opening address, guest speaker RADM L. D. Coates, USN, Chief of Naval Research, indicated that, ". . . . in learning how to detect and combat infectious disease caused by organisms disseminated in the air, we are also gaining valuable knowledge of how to control the processes of infection generally. The data we are amassing does not have to await the emergency of the biological attack to be useful but can be and is being employed already in improving the resistance of man, his livestock and his food crops, to infections of epidemic proportions." The admiral told the assembled officers that they were fortunate to have this opportunity to visit laboratory facilities which are unique in their focus on the problems of chemical, biological and radiological defense techniques.

BGEN Fred J. Delmore, Commanding General, Edgewood Arsenal, in officially opening the sessions, discussed some of the significant advances made in the chemical and biological sciences since the first seminar was convened, and stressed the importance of stepping up the research and development program in order to cut down on lead time from concept to delivery of equipment to troops.

Following an address by Dr. Housewright, titled, "Fort Detrick – Past, Present and Future," the first day's session came to a close with a "Smoker" at the Officers' Mess.

Session chairmen were: CDR W. G. Roessler, LT V. L. Wolfe, LCDR J. T. Duff, LCDR E. J. Norris, LT R. E. Boyle, CDR R. F. Jaeger, LCDR L. L. Kupferberg, COL J. Hebbler (Edgewood Arsenal), and CDR R. D. Housewright.

The program included a tour of Fort Detrick's facilities, including the Simulant Production Plant, the Animal Farm, Medical Bacteriology Division, Crops Division, Aerobiological Facilities and Test Chambers, Physical Defense Division, and the new Bio Math Building.

One day was devoted to a tour of Edgewood Arsenal, Edgewood, Maryland, where the reservists were given a briefing on the Chemical Agents Research program, followed by a field demonstration.

CDR Leon P. Eisman, USN, headed a closing session on "Naval Research Reserve and Biological R&D Programs." Participating in this session were CDR Frank H. Langdon, USNR, Research Reserve Officer, ONR; and Dr. R. D. Reid, Director, Biological Sciences Division, ONR, and members of his staff.

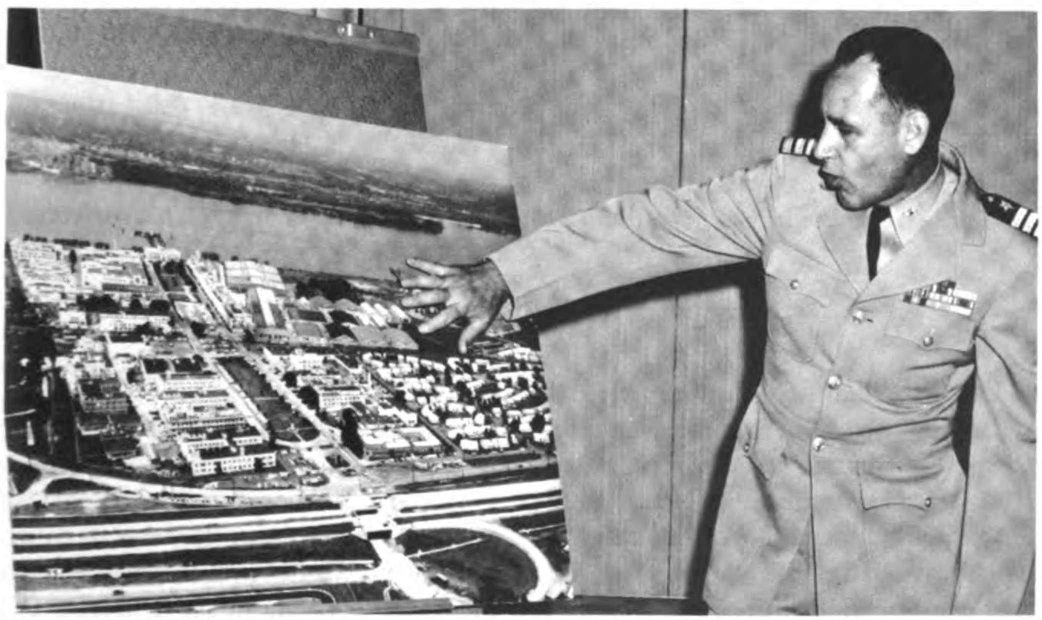
An analysis of answers to the evaluation questionnarie completed at the close of the seminar demonstrated that the meeting was of high quality and left no doubt as to the excellent impression gained concerning the technical knowledge and competence of the speakers.

Eleventh Annual Naval Research Reserve Seminar

The Eleventh Annual Naval Research Reserve Seminar was held at the Naval Research Laboratory, Washington, D.C., from July 14 through July 27. The officers who attended were welcomed by the Laboratory's Director, CAPT B. F. Bennett, USN, who introduced the Chief of Naval Research, RADM L. D. Coates, USN. RADM Coates reviewed several recent naval research projects and their applications.

RADM L. D. Coates, USN, Chief of Naval Research addresses reservists at opening of seminar held at NRL.

During the NRL seminar, CAPT Bradley F. Bennett, USN, Director of NRL, explains program for modernizing the Laboratory.



Naval Reserve Research Company 5-9, headquartered at NRL, sponsored a luncheon for the opening day. CDR H. D. Cubbage, USNR, Commanding Officer of NRRC 5-9, introduced the guest speaker, RADM L. D. Coates, who discussed the role of ONR in foreign research. Other guests included CAPT B. F. Bennett, USN, Director; CAPT T. B. Owen, USN, Director of Administration; CAPT J. J. Santry, USN, Chief Staff Officer, all of NRL, and CDR F. H. Langdon, USN, Fifth and Sixth Naval District Research Reserve Liaison Officer, ONR.

Talks and demonstrations were arranged by the scientific divisions to cover the broad spectrum of research being performed at the Laboratory. The talks concerned such current subjects as microelectronics, lasers, plasma physics, nuclear research, satellite detection, and many other technological developments. Tours were conducted through the Betatron, Linac, 5 Mev Van de Graaff, the NRL reactor, and hot cell facility. In addition, the Engineering Services Division presented a review of their support facilities. A highlight of the seminar was a one-day tour of the Chesapeake Bay Annex, located about 40 miles from Washington, where the officers saw the Madre radar, the 150-foot tracking radar, a hypervelocity gas gun and other research facilities.

LT P. R. Lawver, USNR, of the Military Personnel and Plans Office at NRL, was assisted in the conduct of this seminar by NRRC 5-9 reservists CDR C. H. Chrisman, USNR: CDR C. F. White, USNR: and LT T. J. Rauen, USNR, all of whom are civilian scientists at NRL.

LCDR Lindberg

LCDR Kennedy

New ONR Reserve Assistants

AT SAN FRANCISCO

LCDR William S. Lindberg, Jr., USNR, reported to the Office of Naval Research Branch Office, San Francisco, for duty as Executive Officer and Research Reserve Assistant on May 27. Prior to this assignment, he completed a tour of duty as Commanding Officer, Military Department on board the USNS BARRETT, operating under the Military Sea Transportation Service, Pacific.

A native of Seattle, Washington, LCDR Lindberg enlisted in the Naval Reserve in December 1943, and was assigned to the V-12 Program at the University of California, Los Angeles. He was commissioned an ensign in February 1946, and received his B.A. degree from the University of California, Los Angeles, in June 1949.

A short orientation cruise aboard the USS MONTPELIER (CL57) and assignment to PGM25, which took part in Binini operations, followed commissioning. In June 1947 he was released from active duty and returned to study forestry at the University of Washington.

Ordered back to active duty in June 1948, LCDR Lindberg was assigned to CINCPACFLT Staff in Communications. During the Korean conflict, he was assigned to the USS WINDLAM BAY (T-CVE 92), also in communications. This was followed in April 1952 by an assignment to COMTHIRTEEN Staff in the Naval Reserve Electronics Program; while there, in September 1953, he was selected for the TAR Program.

During 1956 and 1957 he returned to sea, serving aboard the USS CARTER

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HALL (LSD 3) as Operations Officer and, for a short time, as Executive Officer. While on this assignment he participated in the Arctic resupply of 1957.

LCDR Lindberg spent the years 1958 through 1960 as Commanding Officer, U.S. Naval Reserve Training Center, Las Vegas, Nevada. His transfer to the BARRETT took place in February 1961.

AT PASADENA

LCDR Thomas J. Kennedy, USNR, relieved LCDR N. L. Fish, USN, as Reserve Assistant, ONR Branch Office, Pasadena, on July 11. LCDR Kennedy's last duty prior to reporting to ONR Pasadena was that of Surface Program Officer on the staff of the Commandant, Eleventh Naval District, San Diego, California.

LCDR Kennedy received his early education at Martinez, California. He later attended Saint Mary's College at Moraga, California, and was graduated from the U.S. Merchant Marine Academy at Kings Point, New York in 1944. He served with the Merchant Marine until 1946 and then returned to civilian life.

In 1952 he reported for active duty with the Navy, and he has served in varied billets at sea and shore since that time. Sea duty included service as Aide and Flag Secretary, Commander Amphibious Group ONE in the Flagship USS ELDORADO (AGC-11); Electrical Assistant, USS ESSEX (CVA-9); Navigation Officer, USS SITKOH BAY (T-CVE-86); and Assistant Gunnery and Machine Gun Control Officer, USS HELENA (CA-75). Shore duty for LCDR Kennedy included service at Lynchburg, Virginia, as Commanding officer, Naval Reserve Training Center.

Major Goals — Continued from Page 9

It is implicit that while various agencies contribute to defense oceanography, the converse also occurs. As we have already seen, this is particularly true of programs sponsored by the Office of Naval Research. It is also true of the work of the Oceanographic Office. Nearly one-third of the Navy's oceanographic budget is devoted to supporting research in universities and private laboratories. Thus, the Navy's support of basic and applied research, amounting to about 22 percent of the entire national oceanographic budget in 1963 and nearly 20 percent over the coming decade, does a very important double duty. It supports the national defense effort, but simultaneously it strengthens basic science upon which progress in oceanography so greatly depends.

Surveys and Services — Continued from Page 22

parallel nonmilitary system, or that the Navy system can also serve some nonmilitary users on a not-to-interfere basis.

Very approximate estimates of the cost of developing a world-wide ASWEPS system run about $3 million annually for the R&D phase, totaling $20 million. Operating costs will run very nearly another $3 million a year thereafter. The latter are not included fiscally in the National Oceanographic Program.

IN THIS ISSUE

Oceanography in the Years Ahead

A Navy-led committee of the Federal Council for Science and Technology has produced a far-sighted plan for fostering the growth of the science of oecanography during the next ten years in both basic and applied fields of endeavour. The origin of the plan and a number of implications of the long-range thinking it embodies are described here.

NAVAL RESEARCH REVIEWS publishes highlights of research conducted by Navy laboratories and contractors and describes important Naval experimental facilities. Manuscripts submitted for publication, correspondence concerning prospective articles, and changes of address, should be directed to Code 740, Office of Naval Research, Washington, D.C., 20390. The magazine is listed for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Subscription price: $1.50 per year in the U.S. and Canada; $2.00 per year, foreign; $0.15 per individual copy. The issuance of this periodical approved in accordance with Dept. of the Navy publications and printing regulations.

EDITOR: Richard D. Olson

Oceanographic research ship JOSIAH WILLARD GIBBS, a former seaplane tender, as seen from above. The GIBBS, which is operated by MSTS for Hudson Laboratories of Columbia University under contract to the Office of Naval Research, will be joined in this Nation's oceanographic effort by a number of new research vessels in the years ahead. The important role to be played by these ships is discussed throughout this special issue.

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