AVAL RESEARCH

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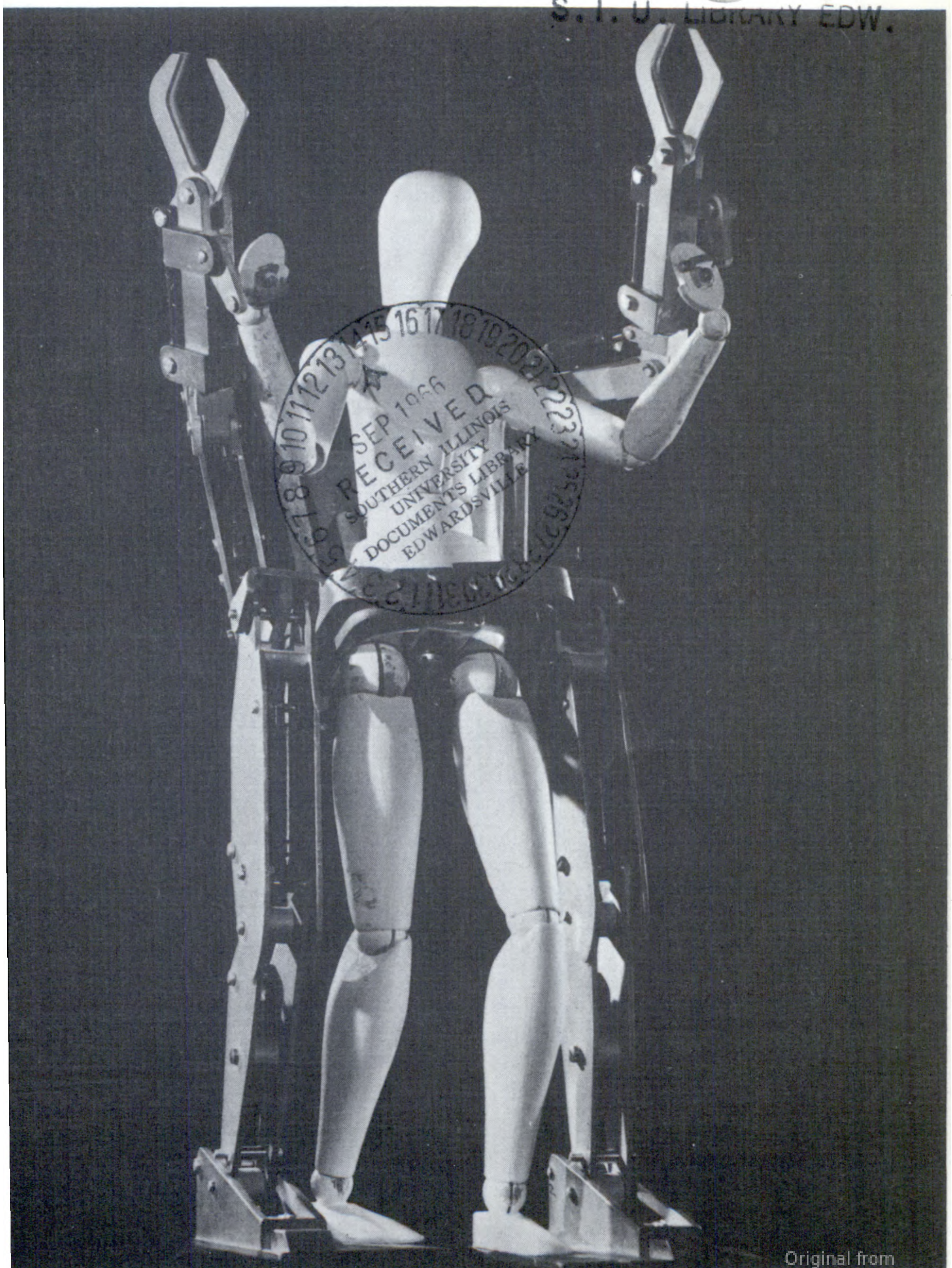
20th Year on the Frontier of Science



The Summer Study

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Vicennial Article

Summer Studies and some are not—
Jerrold Zacharias

On November 6, 1959, the Chief of Naval Operations stated: "The world is full of reports and the Navy has had its share of them. I am concerned that many of the recommendations made in (these) reports....pertaining to research and development are overlooked, with the result that insufficient action is taken." He therefore requested "a summary of recommendations of all research and development reports, including the action taken on each recommendation, the activity processing the action, and the degree of complying with the recommendation. Among the reports that I have in mind are LAMPLIGHT, the Killian Committee, NOBSKA, the Robertson Committee, Project MONTE, the report to the Jackson Subcommittee concerning undersea warfare....and reports of similar stature submitted within the last five years."

Fully half of the examples, identified in this request as "reports...of stature," are the final reports of summer studies, while the others are instances of the traditional committee report, which is the classical device for committing to paper what is hoped is the best informed consensus on a given complex of issues at the time. The historical significance of this document lies, therefore, in the fact that by 1959—the tenth anniversary of the birth of the summer study—the results of this kind of endeavor routinely commanded the attention of the Navy right up to the top, while the character of the summer study as a new activity was yet to be recognized—as evidenced by the random manner in which these studies are interspersed among quite different things in the enumeration.

To make sure of this recognition once and for all, it is our purpose here to discuss the summer study as a well developed, knowledgeably managed pattern of organization and procedures that has proved particularly successful in attacking certain tasks which require unusual foresight and judgement. We shall summarize how this pattern has evolved and proliferated, describe its parts, and trace the impact which such studies have had on the turns of technical innovation and renewal in the Navy.

Chronology and Evolution

In the period since the summer of 1948, when, in the township of Lexington, Massachusetts, the first of the summer study groups convened as a kind of

*Since this article was written, Dr. Weyl left ONR to become Special Assistant to the President, National Academy of Sciences.

latter-day gathering of minutemen, called out to wage a brisk season's campaign on one of this country's tougher problems, the Navy has conducted 18 such studies, the most recent one this summer. They have varied in size from the gathering of a dozen or so knowledgeable scientists, such as PEBBLE (1965), for the purpose of re-examining a persistent problem, to efforts which involved better than a hundred experts in the attempt to anticipate the future requirements for and instrumentalities of entire Navy missions, such as LAMPLIGHT (1954) and SEABED (1964). In variety of scope, they have ranged from a central concern with some particular emergent technology and the spectrum of its prospective uses, such as Project METCALF (1951), to the examination of the concerted use of all relevant means for the accomplishment of a specific Navy task, as—for instance—the WHITE OAK Study of 1958.

At least a dozen such studies have now been conducted under other than Navy sponsorship, at first in connection with problems encountered by the other military services and more recently in a variety of non-military contexts. A cursory inventory and some perspective on their historical sequence will help to identify the salient features of this institution, which, for a broad range of issues, has been found extraordinarily useful in the decision processes of the government.

The Early Navy Studies

The first of its kind, as indicated, was Project LEXINGTON which took place in the summer of 1948. Its aim was to achieve a better understanding of both the difficulties which would have to be overcome in the achievement of nuclear-powered flight and the operational gains to our military forces which could be expected to result therefrom. This was an issue which, in the late forties, had impressed itself on military scientists as particularly complex and important. Encouraged by the Office of Naval Research, which helped in providing the link to the scientific community, the Atomic Energy Commission accepted a proposal from the Massachusetts Institute of Technology to conduct an intensive examination of the various scientific, engineering, and operational factors which could be foreseen as relevant to such a development. Evidently, this required a highly interdisciplinary team, involving physicists, metallurgists, aeronautical engineers, economists, operations analysts, *etc.*, which would not normally be found in any one place and which could be brought together only for a limited time during a period of relatively high general availability. Thus the idea of a summer project at a reasonably pleasant, sequestered, but not too inaccessible place developed quite naturally: Under the leadership of Dr. Walt Whitman, a group of about twenty scientists assisted by consultants and other short-term visitors, stayed in session all summer at Lexington to carry out this study.

In view of the subsequent lack of decisiveness regarding the aircraft nuclear-propulsion program, one might well ask whether this lack of tough-minded decisions can be traced in any way to flaws in the LEXINGTON Study, given that it was the first of its kind. It is true that no comparable projection was made at the time for the future of chemically powered vehicles, both airplanes and rockets, which would perhaps have permitted an earlier appraisal of the competition which nuclear-powered flight had to face in the end. In all other respects, however, the study has withstood the criticism of hindsight well. In particular, it provided experience and built up confidence in the use of this approach to problems as formidable as that of nuclear-propelled flight.

The next study—Project METCALF—which was similarly oriented at an emerging technology, benefited from this experience and paif off with a considerably more persistent impact on program commitments. Conducted during the summer of 1951 under an ONR contract with Harvard University, its subject was the military role of infrared detection. Perhaps, because the scientific disciplines and the related operational considerations which are basic to military infrared detection were pursued, at the time, with more uniform intensity than those underlying aircraft nuclear propulsion—with a resulting edge in the chance of achieving real understanding—Project METCALF had greater impact than LEXINGTON. Of historical interest, moreover, is the fact that the study leader of METCALF was Dr. Donald F. Hornig, now Science Advisor of the President, and that the group members included Dr. Harvey Brooks, now Dean of Applied Science and Engineering at Harvard, and Dr. E. G. Fubini, now Group Vice President of IBM—emphasizing the significance of summer studies for introducing imaginative scientists of promise and challenging problems of defense technology to each other.

Even more decisive for the entire future of the summer study was Project HARTWELL. Acting as coordinating agent for the Navy, the Office of Naval Research conducted this study under contract with the Massachusetts Institute of Technology in 1950. In contrast with the other two early examples, this study addressed itself to an operational warfare mission, and its objective was that of drawing up a plan to advance and exploit contemporary technology across the board for the purpose of improving a particular mission performance. Originally, the problem was identified as that of detecting submerged and snorkeling submarines, a matter which the growth of the Soviet submarine fleet in combination with the evident dependence of the recently forged NATO alliance on U.S. supplies had brought to a critical point. The discussions between MIT and the Navy of the prospective scope of this study provided the historical setting for the now famous aphorism that "the real problem of the Navy is not undersea warfare but overseas transport." The scope of HARTWELL was therefore broadened to "The Security of Overseas Transport," the title of its massive final report. Led by Dr. Jerrold Zacharias and involving a total of 33 full-time study members, Project HARTWELL was convened from early July to the end of August at the Lexington Field Station of MIT. In matters of approach, conduct, and impact, it was to become exemplary for the studies of the next ten years.

The Mature Pattern of Defense Technological Studies

The Navy's improved understanding, due to HARTWELL, of one of its (then) pivotal problems had an electrifying influence on several segments of its research and development program. Whether as a consequence of this striking success or of a combination of other factors, the pattern caught on, and the year 1951 became the year of defense technological summer studies: The Navy continued under Project MICHAEL its preoccupation with certain aspects of undersea warfare; the Air Force, now turning to MIT, conducted, under the name of Project CHARLES, a thorough examination of the problems of continental air defense; and the Army sponsored, under Project EAST RIVER, an analysis of civil defense with the assistance of the other two services and simultaneously organized its own first major summer study, Project VISTA. Conducted under contract with the California Institute of Technology, this latter study analyzed the problems of weapons, techniques, and tactics for the support of ground troops in the full spectrum of warfare environments which the changing world situation and the growing variety of weapons were opening up.

The work of Project CHARLES and MICHAEL spawned, as a consequence of essentially similar developments, the creation of Lincoln and Hudson Laboratories, respectively. Differences in service tradition, technologies involved, and the perceived urgency of the problems account for the differences in size and history between these two laboratories. Similar factors were to affect the function and rationale of summer studies generally: Project EAST RIVER and Project VISTA were, and remained for some time, controversial—especially the latter's emphatic insistence on building up what we should now call our limited warfare capability, which was echoed by General Maxwell Taylor in his book "The Uncertain Trumpet" eight years later, there having been apparently no significant change during this time.

Undaunted by the difficulties which had been encountered by the Army, the Navy continued to pursue the pattern of HARTWELL when, in 1954, it came to analyze—once more in partnership with MIT—its own role in the air defense of the United States. This was Project LAMPLIGHT, which in scope and detail established a record for strategic defense studies. It was also one of the largest studies conducted to date, involving a total of 87 full-time participants for the period from October 1954 to February 1955. Once again the group assembled at the Lexington Field Station under Dr. Jerrold Zacharias' leadership.

Three further studies of progressively smaller impact round out the cycle of the Navy's "classical" defense technological studies: NOBSKA, which was held in the summer of 1956 and dealt with the threat and the opportunities offered by the nuclear submarine, turned out to be every bit as significant as HARTWELL and LAMPLIGHT. It was the first of the Navy studies conducted under contract with the National Academy of Sciences, whose Committee on Undersea Warfare administrered the effort and succeeded in providing for considerably more active participation by Navy in-house scientists than had been the case in the previous studies. Project MONTE, held in the summer of 1957 at the Naval Postgraduate School, determined the Navy's stake in, and proposed a projected program on, sea mine countermeasures. Finally, Project WHITE OAK, held at the Naval Ordnance Laboratory of that locality, returned in 1958 once more to the issue of the security against submarine attack of the sea lanes connecting the NATO allies.

Further Extensions

The next four to five years were characterized by a gradual filling up of the spectrum which the earlier studies had spanned. Remaining confined to matters of national defense, these studies were addressed respectively to problems concerning scope and emphasis of research endeavors, to threat and opportunity analyses regarding new technological capabilities, and to the enhancement of performance in certain warfare areas. Other not-for-profit organizations, such as the Institute for Defense Analyses, the Scripps Institution of Oceanography, and Lincoln Laboratory were added to the list of contractors alongside MIT and the National Academy of Sciences.

Until the SEABED Study of 1964 at Monterey, the Navy's study effort showed no significant further modification of the established pattern: ATLANTIS, was held in the winter of 1959 at Lincoln Laboratory on techniques of ocean surveillance; SORRENTO, that Summer at Scripps, on the principles of non-acoustic submarine detection; WALRUS, in 1960, once again by the Committee on Undersea Warfare of the Academy, on the wartime use of the U.S. Merchant Marine; SOUTH LINCOLN, in the winter of 1962, on POLARIS command communications; STARLIGHT, that same summer, on threats and opportunities of space capabilities for the Navy; and the SONAR SIGNAL STUDY, in 1963, under an IDA contract at New London.

New ground was broken by Project SEABED (1964), which examined operational need and technical opportunity. It determined this country's requirement for future seabased strategic deterrents beyond the Polaris/Poseidon family of systems and defined the research and development which must be done in order to insure that the option of acquiring such systems can be exercised economically and on time. Its conduct followed upon and was integral with a four years' effort of research, exploratory engineering, and systems analysis which was designed—within the framework of the Navy's total research and development program—to advance and consolidate scientific knowledge and emerging technology with respect to the future of seabased deterrence. With a reservoir of potential capabilities thus experimentally explored, SEABED could take a searching look at the intricate fabric of interaction between long term military requirements and the fresh alternatives for meeting them that are offered by contemporary science, giving this study a significantly broader scope than the traditional concerns with either the threat posed by a particularly imminent danger or the specific opportunities of an emergent technology. Moreover, Project SEABED differed from its predecessors by employing mostly members of the Navy's own establishments instead of being conducted under contract.

Starting with the early sixties, finally, successful use began to be made of the summer study approach in non-military contexts. In the course of the last three years, the development of national objectives in space, the manner of achieving reforms in the education of our children, the analysis of problems relating to the pollution of our environment, and attacks on the difficulties which arrest the rise of agricultural productivity in developing countries have all been the subject of summer studies—organized and conducted in the manner of the characteristic defense technological study. The original designers of the tool, the Massachusetts Institute of Technology and the National Academy of Sciences, pioneered the transfer of the pattern into the world of civil issues.

Rules for Design*

Any summer study begins with its terms of reference which delineate the scope of the subject to be studied. This scope should have a broad permissive envelope, but "under no circumstances should it be mandatory that the project cover the tremendous scope that any simple problem involves." The ramifications of a really pivotal single issue need no elaboration, and no summer study could effectively deal in any one instance with all of them. Hence, for each study there also should be defined a hard core of subject matter, the review of which is a mandatory assignment, and—unless something is added to the understanding of this hard core—the study should not be considered as having achieved its aim.

An inadequacy in the breadth of scope, laid on for the LEXINGTON Study on nuclear-powered flight, was pointed out earlier as was the insistence of the MIT managers of the prospective Project HARTWELL that its scope be defined to include all measures assuring overseas transport, such as ports, mines, air transport, weapons, *etc.* There are several instances of the reexamination of results of later projects, one or several years after the original work was completed. Wherever corrections proved necessary, they stemmed from inadequacies of scope which prevented competitive alternatives of the programs or solutions proposed at the time from being fully analyzed.

Organization and Staffing

After the scope of the enterprise has been laid out in the terms of reference, the actual study organization begins with the selection of a strong steering group of at least five persons, not just a single study leader. A measure of divergence of thinking and much originality must be built into this steering group, and—while the director should have a strong personality—he will have to count on playing a less important role than the steering group. This group plans the major activities of the study, assembles the team of participants, and assures that they receive such preparation as may be required; it paces and guides the study effort while in progress and, finally, reviews the report produced and organizes the presentations of the results to potential users, generally in meetings with top echelon representatives of the sponsoring agency.

Let one example be given of many that could be used to illustrate the independence of thinking which the leadership of a summer study must be able to develop. The bold concept of a chain of radar stations in the Canadian Archipelago north of the Arctic Circle was evolved by Project CHARLES as a way to give this country the necessary warning time of an attack by bombers. For much of the year, access to the stations would be only by air, and this made the whole scheme very expensive. In Jerrold Zacharias' words: "Cost considerations therefore necessitated breaking away from the traditional

*In this section we shall draw heavily on statements on summer studies and their organization made on numerous occasions by Dr. Jerrold Zacharias to whom the institution of the summer study owes much of its character. In particular, what is said in quotation marks comes from the unpublished manuscript of an address delivered by Dr. Zacharias in March, 1961, at Harvard University, under the title "Scientist as Advisor."

union-like specialization still quite prevalent in our military forces. One member of the Lincoln Laboratory said that many military installations required cooks for the drivers and drivers for the cooks. In order to get around this problem of large staffs, the Project had to invent on the spot some automatic devices then not available to the military. Such simple mechanisms, in turn, would make it possible for a man to be able to cook, sleep, tend his chores, tend to communications, man the radar, and generally act like the general purpose human being that any camper must be. As soon, however, as personnel requirements were kept low, it became necessary to make sure that the human problem of that dreary mosquito-bitten existence was possible."

Another important aspect—indeed, a last tempering trial of any summer study—is the final acceptance of its major recommendations. A gauntlet of committees will have to be faced, each established to review the conclusions which its predecessors reached on the proposition of the study. This again is something for which spirit and endurance must be built into the leadership of the group.

Obviously, participants in such efforts should be bright, intelligent, and articulate. They will, therefore, always be people who are already very, very busy: Many scientist who have become important in defense matters first attracted attention through their contribution to a summer study. Moreover, they should be capable of what might be called general-purpose thinking. Numerous first class specialists will readily come to mind, but what is needed are men capable of jumping into brand-new problems; special knowledge can be drawn upon by bringing in specialists for testimony and consultation sessions.

A balance must be struck between participants who think in terms of relatively short-range concepts and those with a predominantly long-range outlook. Under no circumstance should they be considered or consider themselves to be representative of a particular organization, discipline, or anything else—they represent only themselves. In particular, one or two especially independent thinkers of acknowledged integrity ought to be included for leaven and to keep the study's conscience on the alert.

A final word is needed on the study report. Although it should be clear by now that summer studies are not principally a mechanism for the generation of a final report, there is always the danger that—since there has got to be one—people start getting preoccupied as early as the first or second week with its form. "James Thurber said something about that in his 'Fables For Our Times.' He said: 'Don't get it right, get it written.'" For formal presentation, such reports have been found most useful if they contain a succinct summary of the material which has been worked over by the study—the hardcore, firm recommendations—and a group of appendices providing substantive detail and background material.

Size and Duration

The wide spectrum of studies on which we can now look back identifies the optimum number of participants as from thirty to fifty, covering a suitable range of disciplines and—even more important—representing different frames of mind. The costs of a summer study are therefore far from trivial, amounting to $100,000 to $150,000 per month if participants are assumed to be compensated at their regular rate.

It is important that study subject and leadership are harmonized to produce an atmosphere where work goes on day and night seven days a week. Even with this intensity, it takes approximately a month before the participants start producing, for they must get to know each other, they must get to know the problem, and they must get to know the questions as well as some of the answers. A study substantially shorter than two months is under a severe handicap, a three-month session is better, four months gets to be long, and a study lasting five months is almost impossible to arrange for busy people.

Impact on Naval Technology

In addition to affording a clearer understanding of the issue under investigation, the most important product of a summer study is that of inspiring new proposals for work which bring new ideas and new faces into the action. On this score, no study can ever be a complete failure, for—even if there is no follow-through on the part of the sponsor—one will be made spontaneously by some of the participants as they get back home. Although only the most important turns of naval technology that have been triggered by summer studies can be pointed out here, it should not be forgotten that equally pervasive, if less dramatic, contingent programs have been carried out and project mutations have occurred which did not wait for, nor were ever recorded in, summer study reports.

Undersea Warfare Studies

The very first of the undersea-warfare studies, Project HARTWELL, established a coherent perspective on practically the entire range of facets, technological as well as operational, which were found to affect our ability to safeguard the use of the seas in the presence of enemy submarines. For years to come, this gave much structure and vitality to the Navy's ASW program, providing a road map for many of the ensuing developments, some of which reached the operational stage in the later years. Notable among these are the use of helicopters in ASW; torpedoes with an initial air trajectory, such as ASROC and the later SUBROC; radars specifically pointed up for snorkel search; the tactics of SSK and the use of airborne hunter-killer units; the potential of atomic weapons as well as of new power plants, such as fuel cells and closed-cycle engines; and the development of improved communications for submarines.

In addition to creating this greatly broadened understanding of the entire problem, the HARTWELL study proved catalytic for two major programs. Its arguments provided the added margin of persuasion that was needed to start the development of a modern high-speed merchant man, giving us the Mariner class. And on the other hand, what it could demonstrate about the operational effectiveness as well as the technical feasibility of acoustic surveillance gave a

—Continued on page 24

Airglow and Its Photography from Gemini IX

Airglow is emitted in the high atmosphere over the earth at all times, but is so faint that even far from city lights on a moonless night it is just barely discernible to the human eye. In the daytime it is completely swamped by sunlight. Airglow brightness is comparable to that of white paper illuminated by a candle at a distance of 100 feet. Rocket observations by scientists of the Naval Research Laboratory first showed in 1955 that most of the night airglow shines from the region between altitudes of 45 and 60 miles.

The energy responsible for airglow comes from the sun's ultraviolet light, which is absorbed by the molecules and atoms of the atmosphere during the day. Green and red airglow is released by oxygen atoms, yellow light by sodium atoms, and infrared light by hydroxyl radicals (molecules of OH). The invisible infrared airglow is so bright that if our eyes could see it, we would have perpetual twilight.

The discovery of sodium airglow was particularly intriguing to scientists, because sodium is not an atmospheric gas. How do sodium atoms get into the high atmosphere? The answer is not clear, but the following sources are theoretically possible:

- Meteorites that enter the earth's atmosphere and vaporize about 60 miles above the ground.
- Sea spray that carries salt (sodium chloride) high into the air.
- The explosion over the ocean of atomic bombs, which boil the sea and drive the sodium high into the stratosphere.
- Volcanic debris, such as that hurled into the atmosphere during recent eruptions in Bali.

Many scientists believe that the ever-present sea spray may be the largest source.

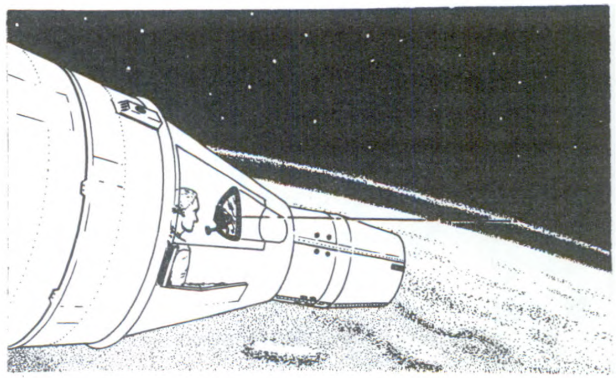
How much sodium is present in the upper atmosphere is uncertain. Estimates range from one-half to two tons of free sodium. The amount of combined sodium (salt) is very much greater.

What makes the sodium glow at a particular altitude? Chemical reactions involving free oxygen atoms are necessary. The ground-level oxygen which we breathe is composed of two-atom molecules and is relatively inactive chemically. Higher than 60 miles above ground, solar ultraviolet light decomposes the oxygen molecules into atoms. There the atoms react with sodium oxide and sodium hydride molecules to release luminescent sodium atoms.

The airglow also contains luminescent potassium and lithium. Lithium was first detected in 1958 after a series of hydrogen bomb explosions. Under normal conditions, lithium and potassium atoms are introduced by meteorites.

Although the night airglow has been studied since the early 1900's, progress in unraveling its mysteries has been slow. Even its most fundamental features, such as intensity and altitude above the earth, have been very difficult to measure from the ground because of its dimness, contamination by starlight, and distortions caused by atmospheric absorption. A still further difficulty is that the airglow is a global phenomenon like the weather and its variations are on

ng depicting photography of airglow
)Gemini IX. The camera and sight
nounted in Eugene Cernan's window
novable bracket. The camera was kept
d steadily at the horizon for the ex-
e time, which was as long as 20 sec-
Command pilot Tom Stafford first
ed the spacecraft to bring the horizon
range of the camera.



Photograph of a 700 mile length of the moonlit northern horizon and the night airglow layer taken from a point over the South Atlantic. The horizon is about 1000 miles away. The darker strip to the left of center corresponds to the portion of the film over which a yellow-orange filter was placed to record the airglow in yellow sodium light. The airglow and the horizon to the right of the dividing line appear much brighter because they are recorded through a filter which admits all wavelengths except the sodium yellow.

the same geographical scale and seemingly just as irrational. Thus, a thorough study requires many observations all over the earth in remote places away from city lights. Even today there are only a few observatories with sensitive light-measuring instruments which regularly make airglow measurements.

The orbiting satellite, particularly the manned satellite, is offering a new and almost tailor-made solution to the earlier problems. From a vehicle which orbits above the airglow layer, the measurements become very much easier. An astronaut observes the layer more or less "edge-on" and thus sees its brightness greatly enhanced. In fact, he sees the airglow as a thin, luminous streak lying just above the earth's horizon line, and he can record its altitude and intensity by direct photography. The orbiting astronaut also can make observations on a global scale, and he can gather world-wide data on the airglow layer in much the same way that a weather satellite observes global weather patterns.

On one of the earlier Mercury flights, Glenn saw the layer clearly, although he had not been told what it might look like. He described it as a thin, luminous "haze layer" lying above the terrestrial horizon, which is an accurate description. Carpenter made some very good eye-estimates of its brightness and height, and Cooper took some remarkable color photos of the layer under difficult conditions by means of a hand-held high-aperture camera provided by Professor E. P. Ney of the University of Minnesota.

The purpose of the airglow experiment in Gemini IX was to add much new data to Cooper's observations. This was to be done by means of a larger camera equipped with color filters and an $f/0.95$ lens. One filter combination allowed the camera to photograph the airglow layer in two of its prominent emission wavelengths: the 5577 A (green) light of atomic oxygen and the 5893 A (yellow) light of atomic sodium. The filters were arranged so that the camera picture was split down the center by a vertical dividing line, the picture on one side recording the oxygen green light, and the picture on the other side recording the sodium yellow light. Fast black and white film was used to keep exposure time to a minimum. Exposure times as long as 20 seconds were required.

The camera which was used in Gemini IX was the General Purpose Camera, developed for the Manned Spacecraft Center in Houston, Texas, and modified for airglow photography by M. J. Koomen and R. T. Seal of the E. O. Hulburt Center for Space Research at the Naval Research Laboratory. The camera was mounted on an adjustable bracket in the pilot's window. The astronauts were required to guide and hold the spacecraft to the correct attitude and fine-point the camera with the aid of an optical sight for the length of the exposure time. This maneuver was accomplished many times by careful teamwork between astronauts Stafford and Cernan on the second and third days of their flight in Gemini IX. Command pilot Stafford controlled the spacecraft and gave time signals, while Pilot Cernan controlled the camera, made exposures, and changed filters.

The Gemini IX vehicle returned to earth on June 6. In spite of an unusually hard splashdown, the astronauts returned camera and filters in perfect condition, ready for future Gemini flights. In all, 44 photographs were obtained. They show global variations in altitude and intensity of the airglow layer. In some photographs, the sodium and oxygen glows are at the same altitude; and in others, the oxygen layer appears to be the higher of the two. The astronauts noticed that at some times the layers seemed thinner and sharper than at other times. The photographs confirm this observation.

So steadily did the astronauts guide the spacecraft that many photographs show star trails with almost no detectable wiggle. This demonstration of ability to control the scacecraft and camera augers well for future airglow studies and astronomical measurement from manned spacecraft.

Ground was broken recently for a $250,000 undersea research facility at the Naval Civil Engineering Laboratory, Port Hueneme, California. The new building will house a pressure vessel capable of simulating the undersea environment at depths as great as 12,000 feet. The vessel, which has an inside clear diameter of 6 feet and a length of 15 feet, will be capable of testing full-scale models of undersea structures and devices. It is scheduled to be operational in 1967.

The Navy's Ocean Research Program–1967

The following account of the plans and expenditures for the fiscal-year 1967 Navy program to be carried out to meet the research obligations of the Department of Defense with respect to national security and in recognition of other national interests in oceanography is excerpted from "The National Oceanographic Program (Fiscal Year 1967)," prepared by the Interagency Committee on Oceanography (ICO) of the Federal Council for Science and Technology. Portions of the Navy commitment to ocean exploration, such as those involving research ship design and construction and ocean engineering are not included in the excerpt, but are discussed in other chapters of "The National Oceanographic Program (Fiscal Year 1967)".

Navy Expenditures
FY 1965–$30,422,000
1966–$31,210,000
1967–$32,149,000

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

OFFICE OF NAVAL RESEARCH

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

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

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

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

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

1967 Program

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

Major program support for basic studies will continue to go to the following institutions:

Woods Hole Oceanographic Institution
Scripps Institution of Oceanography, University of California, San Diego
Lamont Geological Observatory, Columbia University
University of Washington
Chesapeake Bay Institute, Johns Hopkins University
Texax A&M University
Narragansett Marine Laboratory, University of Rhode Island
Institute of Marine Sciences, University of Miami
Oregon State University
Massachusetts Institute of Technology
Graduate Research Center of the Southwest

Most of these institutions are involved in teaching as well as contract research; about 150 graduate students will be supported in fiscal year 1967. Approximately 30 percent of ONR's 1967 research budget has been designated for the operation of ships which either belong to contractors or have been provided by the Navy to support investigations.

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

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

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

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

Ocean Data System—Research relying upon this recently developed system of long-range telemetering buoys will be inaugurated in fiscal year 1967 to support investigations in the areas outlined above.

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

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

Geology and Geological Processes—Sedimentation and geochemistry.

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

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

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

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

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

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

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

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

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

Problems in Undersea Warfare—This exploratory development program is broad in concept, embracing the fields of oceanography, physics, and submarine geophysics and geology. Key elements are bathymetry, seismology, gravity, magnetics, heat flow, bottom and sub-bottom features, signal processing, and theoretical as well as experimental aspects of the dynamics of sound propagation.

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

Continental shelf and Slope Problems—Much of the ONR program bears on problems relating to the continental shelf, although few of the research tasks are so circumscribed as to fall entirely within this geographic region. Some of the areas of concern are associated with the slope. Subjects of interest include the following:

• Sediments, erosion, and sedimentation.

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

• Structural geology studied by geophysical techniques.

• Ecology of marine communities with some emphasis on fouling organisms.

• Biology of marshes, estuaries, and other inshore areas.

• Interactions between the sea and the atmosphere.

• Processes that modify waves upon the entrance of waves into shallow water.

• Internal-wave phenomena.

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

• Currents and their controlling dynamics.

• Surf generation and the effectiveness of surf in moving beach material.

• Processes that shape the coast.

Research activities on the continental shelf were funded at a level of approximately $2.3 million in fiscal year 1966. No significant change was planned for 1967.

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

NAVAL MATERIAL SUPPORT ESTABLISHMENT

The oceanographic research programs of the Bureaus of Ships and Weapons now come under the cognizance of the Chief of Naval Material as a part of the Naval Material Support Establishment (NMSE). The former is now the Ship Systems Command and the latter, the Ordnance Systems Command. The Bureau of Yards and Docks (now the Naval Facilities Engineering Command) and the Deep Submergence Systems Project, also a part of NMSE, report their respective oceanographic R&D efforts as "Ocean Engineering" in another chapter of "The National Oceanographic Program."

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

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

Ship Systems Command

The Ship Systems Command conducts 80 percent of its research in oceanography at two of its laboratories—the Navy Underwater Sound Laboratory (USNUSL) and the Navy Electronics Laboratory (NEL). Its program is directed primarily toward determining environmental factors which are important in underwater acoustics, electromagnetic radiation, and subsurface hydrodynamics. The command has been active for many years in the special problems of the arctic, and it has an active interest in air-sea-ice interaction.

1967 Program

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

In addition to asoustically oriented research, USNUSL and NEL will study the electromagnetic properties of the surface layers of the sea by means of undersea vehciles. The command will continue to support a project at the Naval Research Laboratory on surface effects of the passage of a submarine, beneath the surface.

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

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

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

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

Applied Science Laboratory—Study of microorganisms affecting corrosion.

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

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

Ordnance Systems Command

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

1967 Program

In fiscal year 1967, the command's laboratories will use new oceanographic research ships for experiments important to system design and development and to predict system performance. They will continue to study the behavior of underwater sound in relation to the physical and chemical properties of the ocean. Of particular concern will be the nature and degree of variability of such behavior, both horizontally and with depth, and the extent to which they affect the performance of Naval systems.

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

NAVAL OCEANOGRAPHIC OFFICE

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

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

1967 Program

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

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

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

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

Nearshore Environmental Prediction—This program will infer oceanographic conditions in harbors and other nearshore areas where environmental data are sparse or not available. Prediction techniques have been prepared for surface waves, water temperature, and salinity (density, conductivity). Preliminary investigations have been completed for bottom materials and tidal currents. Investigations now in progress include marine fouling, bioluminescence, underwater visibility, and bottom pressure fluctuations.

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

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

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

Spacecraft Oceanography—This project will investigate and evaluate the possible application of remote sensors and spacecraft techniques to oceanographic data collection and to the development of procedures for effectively interpreting and displaying the data.

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

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

—Continued on page 28

Research Notes

Neptune Limnos

Project Neptune Limnos, the third and final test of the use of merchant ships as "research ships of opportunity" (RSOs), began late in July when the freighter SS EXILONA of the American Export Isbrandsten Lines left Detroit carrying cargo to European and Mediterranean ports. Aboard the ship was a 20-foot mobile sea van that had been instrumented to obtain marine biological and other oceanographic data and samples while the ship cruised at its normal speed. The seven-ton research trailer was placed aboard the EXILONA by the University of Michigan, which is handling the project under contract to the Office of Naval Research.

The objective of the RSO program is to conduct limited oceanographic research aboard commercial ships during their regular runs without interfering with the ship's routine operation. The idea originated in the Oceanic Biology Branch of ONR. Dr. Sidney R. Galler, then head of the branch, was concerned with the difficulty of conducting marine biological research in the open ocean because of the few ships available for this purpose and the cost involved. The Oceanography Subcommittee of the House Merchant Marine and Fisheries Committee encouraged cooperation between the Navy and the American Merchant Marine to carry out the RSO concept. The result was Project Neptune, a series of RSO test voyages. (See *Naval Research Reviews,* Jan. 1965). Project Neptune commenced late in the summer of 1964, when the SS JAVA MAIL of the American Mail Lines carried a sea van from Seattle to Hong Kong.

During the summer of 1965, the second RSO—the SS EXPORT CHAMPION of the American Export Isbrandsten Lines—carried the mobile laboratory van from New York City to Mediterranean ports (*Naval Research Reviews,* Aug. 1965). On this voyage, the van was equipped with a "jet net" developed for RSO use by the General Motors Defense Research Laboratory, Santa Barbara, California. This net gathered plankton live and in good condition, enabling biologists to examine the organisms in their natural state. Previously, the organisms could be studied only in the preserved state at shore laboratories because they die quickly after being caught.

For the first time during Project Neptune Limnos, biological sampling was conducted during an RSO voyage in fresh and brackish water as well as in the open ocean. The project also pointed the way to the greater participation by midwestern universities in oceanographic and marine biological research, which has been confined largely to coastal institutions.

Following completion of Project Neptune, the experience gained will be applied to designing experiments and compact mobile laboratories for operation aboard commercial ships, including passenger liners. With industry, universities, shipping companies, and the government cooperating, a great amount of biological information about the large lakes and oceans of the world can be obtained at modest expense.

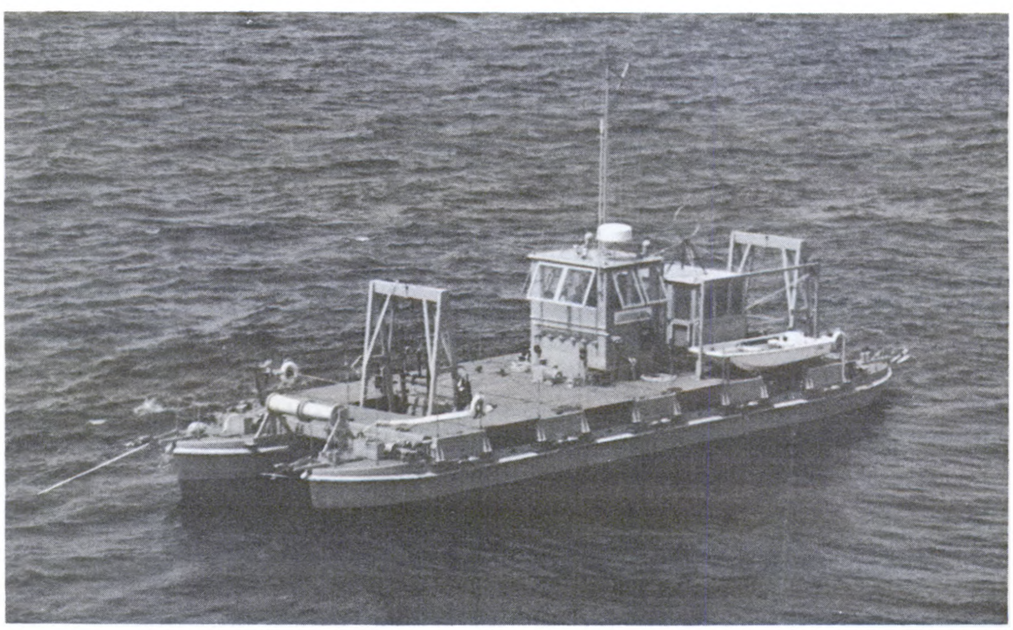
A New Catamaran for Research

A 62- by 21-foot catamaran-style floating research platform built for the Naval Research Laboratory was put through sea trials in Chesapeake Bay earlier this year in preparation for its application to studies of radio-propagated energy underwater. The catamaran can carry 20 tons, including equipment and eight people, and is of sufficient capacity to permit as many as three experiments to be conducted without mutual interference. Most of the experiments will be conducted in the Chesapeake Bay and in other waters along the East Coast.

In general, the facility is of fiberglass construction. For the research to be performed, this material offers three distinct advantages over most other shipbuilding materials: It minimizes the effects of hull metal on the in-air radio signal's polarization; it can be built more easily in sections, which permit the configuration of the facility to be changed according to the requirements of the experiments; and it is of relatively light weight, allowing it to be carried to any body of water designated for study.

The platform is equipped with ship-to-shore radio, sonar, radar, and anchoring and navigational lights. It is stable enough to be operated in seas with waves as high as five feet. Sectioned pontoon modules, which can be filled with sea water, permit the whole facility to be raised or lowered in the water to obtain various free-water deck heights; this feature reduces to a minimum the in-air instrumentation cable runs and aids in maintaining a trim ship.

Located on each corner of the catamaran are four water-jet propulsion units, which are used to maneuver the platform and to drive it at a speed of about 7 miles per hour in case a quick return to port must be made during a storm. The catamaran also carries an auxiliary outboard motor boat to aid in the experiments.



NRL's research catamaran.

Radio communication equipment, power switches, and all controls for steering, engine regulation, and navigation are located in the pilot house on the deck. Winches and lifting frames, which also are mounted on the deck, permit submerged and external devices to be manipulated by the scientists on board. A specially designed shielded room has been provided to accommodate scientific instruments. In addition, there are two cylindrical fiberglass submersibles, in which special equipment for performing electronic measurements can be lowered by cables to various water depths.

Ocean Ice Movement Studied

Techniques for predicting a month in advance the path that a rapidly moving ice flow will take are being developed by the Naval Oceanographic Office through a study of the movement of ice in the North Atlantic Ocean. Last summer, impetus was given to the study by the movement of the ice island ARLIS II into this region. The "island," which was 2 by 1-1/2 miles in length and width and from 40 to 80 feet thick, had been maintained as a research station by the Office of Naval Research since May 23, 1961. During the winter of 1965, it crossed over the Pole and entered the North Atlantic, where, in anticipation of its disintegration, it was abandoned on May 11, 1965. Twenty days after the evacuation, the island commenced to break up.

Through aerial photographic observation, the movement of the disintegrating island was documented, providing important information relating to the forces that move ocean-going glacial ice, the behavior of the ice, and the causes of its breaking up.

The study of the paths taken by, and the disintegration of, such glacial-ice masses, or icebergs, is important because of the threat they pose to trans-Atlantic shipping.

High-Pressure Test Chamber

A high-pressure test and evaluation vessel capable of exerting pressures as great as 20,000 pounds per square inch, equivalent to a depth of about 8.5 miles beneath the surface of the ocean, has been developed by the Naval Oceanographic Office to test instruments designed for undersea operation. The vessel accepts instruments as long as eight feet and subjects them to pressures equivalent to those of any ocean depth. It weighs 18 tons and has a plug-type cover weighing two tons.

Already, several instruments that have been tested in the new chamber at pressures at which they were designed to operate have failed to function properly and thus are being reevaluated. By making such determinations in the laboratory instead of at sea, considerable savings in time and money are being realized.

The USRL is now the USRD

On July 1, the Navy Underwater Sound Reference Laboratory (USRL) of the Office of Naval Research, located in Orlando, Florida, was disestablished and became a division of the Naval Research Laboratory—the Underwater

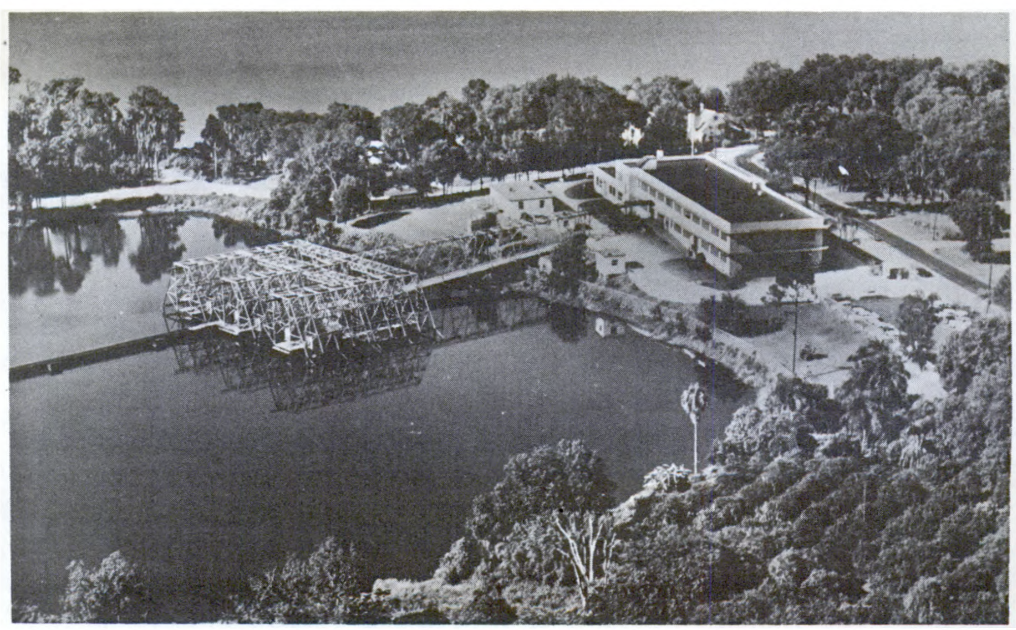
Sound Reference Division. Under NRL, the Orlando Laboratory's program of standards and instrumentation development for underwater sound measurement will be reinforced by the specialized capabilities of related elements of the NRL research staff. In addition, the financial, management, and support services requirements of the Laboratory will be backed up by the service organizations of NRL.

The Underwater Sound Reference Laboratory was established in 1941. At that time, there was a need for an organized program for developing standard hydrophonic instruments and methods for making precison measurements on underwater acoustical devices. Toward fulfulling this need, a contract between the Navy's Office of Scientific Research and Development (now the Office of Naval Research) and the Western Electric Company was signed for the establishment of USRL, with experimental work to be performed by the Bell Telephone Laboratories.

Lake Gem Mary, one mile south of Orlando, Florida, was selected as the site because of the advantages of its nearly circular shoreline and roughly conical bottom. Furthermore, the Florida climate offered assurance that the water would be free of ice the year round; thus, operations would not often have to be suspended because of the weather. In addition, a small lake is more suitable than a stream or a larger body of water, because it is free of interference from waves, tides, and boat traffic.

In 1942, USRL was placed under the management of the Columbia University Division of War Research, which continued to operate USRL until the close of World War II. Three years later, in 1945, USRL was placed under the management of the Naval Research Laboratory. In October of 1946, it was placed under the administrative direction of the Office of Naval Research, where it has remained until today.

The institution's name is in itself a general statement of its functions. It is a reference laboratory not only in the sense that it provides standards for acoustic



The Underwater Sound Reference Division on Lake Gem Mary.

instrumentation but in the sense that problems in underwater sound measurement are sent to it for solution, and newly developed equipment is brought to it for performance evaluation. It also conducts research and development in order to further the science of underwater sound measurement and its application to the solution of underwater sound problems of the Naval establishment.

USRD makes measurements in the Lake and in special chambers in which echoes, temperature, and pressure can be controlled. It has facilities for making absolute measurements of acoustic and most electrical characteristics of underwater sound equipment at frequencies from 0 to 2.2 megacycles, at pressures from 0 to 1000 pounds per square inch (gage), and over a temperature range from 2 to 40°C. It maintains stocks of calibrated underwater sound transducers for issuance to other activities and facilities for the repair of these transducers. Other USRD facilities include a pressure laboratory; high- and low-frequency laboratories; four free-field response pier systems; and two facilities in which limited electrical or acoustical measurements can be made: one consisting of a tube (55 feet long and 15 inches in diameter) for producing pressures up to 8500 psi; and the other a small chamber, fabricated from a Naval 16-inch gun shell (used only for limited electrical tests), for producing pressures up to 15,000 psi.

The new division will remain under the immediate supervision of the USRL chief scientist, Mr. O. M. Owsley.

Obsolete Ordnance Exploded for Seismic Research

In a continuation of underwater seismic tests conducted by the Navy as a part of the Advanced Research Projects Agency's VELA UNIFORM seismic research program, 300 tons of obsolete conventional explosive material was detonated on July 28 at a depth of 4000 feet in the Atlantic Ocean 75 miles east of Cape Hatteras, North Carolina. The explosives were contained in old mines, torpedo warheads, and other ordnance, which was loaded aboard the World War II Liberty Ship SS HORACE GREELEY. The ship was towed to sea, scuttled, and the explosives detonated when the ship had sunk to the prescribed depth.

The experiment, which was conducted for ARPA by the Office of Naval Research, was designed to explore methods for detecting and locating underwater and underground explosions. The results will complement those of similar tests conducted in both the Atlantic and Pacific Oceans earlier this year and last year. By knowning the time and position of such an explosion, exact determinations can be made of the travel times of the seismic waves generated to recording stations in the United States and other parts of the world.

These VELA UNIFORM experiments take advantage of the Navy's obsolete ammunition disposal program, called CHASE, which was undertaken by the Naval Ordnance Systems Command to safely empty the Navy's warehouses of explosives that are no longer useable. Previously, the explosive material had been carefully packaged and jettisoned at sea. As a result of coordinating the two programs, the seismic data is being obtained at very little cost.

The Summer Study—Continued from page 7.
decisive impetus to the development of such systems. Other considerations of perhaps comparable importance were not given the same kind of follow-through—a lag which in some instances has persisted to this day. Examples of these are methods for lowering the turn-around time of transports, the dispersing of port facilities, and the strengthening of harbor defenses.

Project MICHAEL, following in the wake of HARTWELL, provided a yet more secure purchase on the promises and problems of the newly developed approaches to ocean surveillance and submarine search. In identifying the full gamut of contemporary technology which could be brought to bear, especially its more stormily expanding branches, and in projecting the likely results, it could but recommend the establishment of a broadly based laboratory with these considerations as its specific mission. Today, Hudson Laboratory provides major undergirding to the Navy's underwater acoustic systems development and is the keystone in the ARTEMIS program.

A second important skein of developments traces its origin to Project NOBSKA which, half a decade after MICHAEL, reviewed the promises and threats offered by advanced submarine design, especially nuclear power. The electrifying realization that solid propellant missiles would be able to deliver warheads of adequate size, in adequate number, and with satisfactory accuracy, as determined by the then accessible state-of-art in ship inertial navigation, permitted laying down in an incredibly short time the main features of the POLARIS system. This catalytic event remains to date the most outstanding example of what a summer study can do and how it achieves it.

On the other hand, the insistent warnings of NOBSKA that active low frequency sonar work needed to be pursued at a much more energetic scale continued to fall on deaf ears for another two years, and imaginative plans for the exploration of light weight, high flux density propulsion reactors stirred discussion at the time but were not implemented.

In 1958, eight years after HARTWELL, WHITE OAK examined once more the problem of protecting merchant ships—this time, however, from the viewpoint of strategies and tactics based on the use in sufficient number of equipment which is either on hand or readily available. Its main technological impact consists therefore in the advance which it represents in the analytical establishment of a force structure projection. From an operational standpoint, it demonstrated that, at that time, optimum methods of convoy protection required force levels which one could reasonably hope to achieve.

ATLANTIS returned to the problem of the feasibility of ocean surveillance, now with the aim of coping with missile launching submarines. It created a greatly expanded reservoir of alternative approaches and concepts which have furnished the material for many later studies in this area. Not only were all techniques of submarine detection reexamined, but a large number of imaginative systems applications which these techniques might provide were considered. Acoustic techniques were found to continue to have the greatest overall potential, a finding later to be confirmed by SORRENTO. The results of this study affected the direction and level of effort of two major projects, then in the making: ARTEMIS and TRIDENT. Also reemphasized was the need for an adequate surveillance of surface shipping to complement underwater surveillance. This had been a matter of concern as far back as HARTWELL and is now receiving greater recognition in command and control as well as astronautics developments.

One common thread of technology runs through all underwater summer studies: The recommendation of increased emphasis on oceanographic and acoustic research. This has certainly had its share in the evolution of today's broad oceanographic research program and the strength of supporting research facilities. Accelerated by the needs of the POLARIS program, it has now culminated in the establishment of a Center of Ocean Sciences at the Naval Research Laboratory.

Studies of Seabased Deterrence

Up to the mid-fifties, seabased deterrence was the job of the carrier task force—based on a technology that was well understood and vigorously advanced. When, in 1956, Project NOBSKA assembled the mosaic of technical feasibilities that spelled POLARIS, it put the capstone on the development of a seabased deterrence concept whose far-reaching operational consequences were even then being worked out by the Naval Warfare Analysis Group.

No major obstacle appeared to bar the way, as problem after problem in ship construction, missile design, and the integration of navigation and guidance systems was solved. Not until the very instant of deployment was there recognition of the full difficulty in meeting the specific command communications requirements. Only after the establishment of an energetically pursued R&D program, which uncovered potential new approaches to the problem, was a full-fledged study undertaken. SOUTH LINCOLN confirmed what the experience to date had led one to suspect: The Navy would either have to resort to a special-purpose communication system of great cost or rely on improvisation.

Capitalizing on the experience of eight years in designing, building, and finally operating the POLARIS force as an integral part of the Navy, Project SEABED was undertaken to assess the forms which seabased deterrence could and might well take in the course of the next twenty years. Some of the research and development programs to assure the availability of the priority options, identified by this study, are now in progress. More important, however, is the experience which SEABED provided in the derivation of long term military requirements for costly weapons. The effective use in this context of historical studies and socio-political forecasts, along with technological explorations and systems analysis, turned out to be of particular importance. At the same time, the SEABED Study had to make a first bold and comprehensive attempt at understanding, on similar methodological grounds, the need for deep ocean capabilities—both operational and engineering—as a field for an eventually integral national commitment. Here, the SEABED Report set the pattern in scope and structure, even if the substantive conclusion should be revised as subsequent developments deepen our understanding.

Mine Warfare Studies

Projects MONTE (1957), MONTE PLUS 5 (1962), and PEBBLE (1965) considered practically all facets of mine warfare. However, the results in terms of impetus to technological improvements were spotty. The reexamination, 5 years later, of the entire spectrum covered in the MONTE study found that the major conclusions and recommendations were still valid, but that little, if any, progress had been made in the intervening period.

An exception was found in the area of sonar capabilities, where some improvement had been achieved. On the other hand, a continuing serious lag in advances was noted regarding the accuracy of navigation and the integration of mine hunting techniques into total operational concepts. Credit can be claimed by Project MONTE for having breathed some new life into the program on pressure mine sweeping. Its recommendations for the development of undersea workboats, on the other hand, are finding implementation only now in connection with undersea warfare and deep submergence operations—hopefully with spin-offs which may eventually prove useful to mine warfare.

PEBBLE, in turn, addressed mainly the problems of mine and mine countermeasures operations in guerrilla warfare. As such it defined for the first time the kind and quality of technological effort which they require. Of characteristic importance are the problems of swimmer neutralization.

Air Defense Studies

When the Navy, in 1955, subjected its role in the air defense of the North American continent to summer study examination, it emerged with the blueprint for a radically revised, greatly enlivened program in surveillance and command control electronics. As soon as the LAMPLIGHT Report appeared and could be reviewed, a vigorous effort got underway to formulate and launch R&D programs responsive to its recommendations. Perhaps most decisive among the many new departures that took their inspiration from the LAMPLIGHT study are the computer-centered command control systems: The tactical systems for the control of Fleet air defense operations at sea and of the air space over invasion beaches, the centers for the management of ocean surveillance data, and the current generation of Fleet headquarters command posts. Numerous other recommendations, relating to the electronic collection, transmission, and processing of data for air defense purposes, were given prompt support—with lasting effect on the Navy's entire electronics program.

Studies of Emergent Technology

The group of studies which was undertaken specifically to scan the military implications of major scientific advances was, of course, particularly preoccupied with the Navy's research and development program. Some of them gave it new turns and decisively enriched it; others, and this is at least as important, gave the assurance that the on-going efforts were by and large on the right track, not missing any important bets.

METCALF (1951) identified the importance of military applications of infrared optics, determined the principal directions and techniques of exploitation, and—in particular—recognized the operational significance of the Sidewinder anti-air missile which was then being developed as a bootlegged project at the Naval Ordnance Test Station.

The SORRENTO Report (1959) is a physicists' review of nonacoustic submarine detection methods. With the characteristic courage of summer studies, it demonstrated that the effects whose physics was then understood fell by two orders of magnitude or better below the threshold of being useful, while the effects that might prove to be useful were not understood. Those of its recommendations that have been implemented proved fruitful, and its caveats—whether heeded or not—have on the whole proved to have been justified.

Project STARLIGHT spelled out the rationale for the Navy's efforts utilizing space capabilities for both offensive and defensive purposes. It presented the hardest quantitative information to date on anticipated requirements, foreseeable performance, and eventual costs of satellite systems in the three contexts which long ago had been sharply identified as the ones of principal Navy interest: Navigation, reconnaissance, and communication.

In particular, it returned once again—as several of the summer studies in earlier years had done—to the problem of ocean surveillance. Where HARTWELL had identified the contributions that long range sound propagation at the lower frequencies could make in this context, and LAMPLIGHT had started the systematic exploitation of the modern computer for mastering the implied data handling task, STARLIGHT now added the possible use of satellites for observation and data transmission. Notwithstanding all of these technological turns of the road, the issue of where to go is still very much with the Navy today, and further summer studies are planned to clarify it.

The SONAR SIGNALS Study of 1963, finally, must be rated along with MICHAEL as one of the most highly technical summer studies: It was felt that on the one hand the advances in computer art and electronic signal processing—especially as developed under the impact of the radar requirements for early missile detection—and on the other hand the accumulated insight into the parameters of ocean acoustics and their statistical variation warranted a thorough re-examination of the field of sonar signal processing. The exercise did, in fact, turn out to be fruitful for it opened up the possibility of determining and eventually exploiting, in terms of signal-versus-noise procedures, certain characteristically nonrandom aspects of ocean acoustic noise.

Prospects for the Future

This completes our panoramic survey of the evolution and the impact of the summer study as a characteristic research and development institution. From the mid-fifties onward, summer studies became regular activities, conducted in considerable number and engaging summer after summer most of the prominent members of the scientific community. A wide variety of subjects of graduated difficulty is thus being studied by teams that operate essentially according to the rules we have outlined.

Indicative of the development of the medium to date are Project FORECAST, conducted in 1963 by the Air Force, and the Navy's SEABED Study of 1964. To an increasing extent, the military departments have developed the ability of solving their problems without resorting to the special effort of a summer study. In size, effort of preparation, and difficulty of question attacked, these two studies therefore set a new level. At the same time, they tend to lay out an action program of larger span than their predecessors, providing a more slowly exhausted store of recommendations for implementation.

Against this background we predict that the summer studies of the next 20 years will change, in general, in the following ways:

- Increase in size and sophistication of effort.
- Require an ever longer lead time for planning and preparatory work. State-of-art information will have to be brought together; and often it will be necessary to complete specifically relevant programs of laboratory experimentation, field tests, and operations analysis before the study can get underway.
- Involve in an increasingly essential way the contributions of the social and behavioral sciences, for the problems will less and less often deal only with overcoming physical performance limitation of equipment and rigors of environment. Generally, the "hearts and minds of people" will figure as important factors.
- Be more widely spaced than they were during the last ten years.

Wherever this evolution may lead, it is important to keep in mind that first and foremost the summer study is an unrivalled mechanism to bring people together for a few weeks in order to prepare the ground for new things, to engender enthusiasm for starts along fresh lines of endeavor which will spread to broader segments of the scientific community, and—giving the final words once more to Jerrold Zacharias—to engage in "the process of understanding seemingly simple things...the most difficult and time-consuming of them all."

—The Navy's Ocean Research Program—1967—Continued from page 18.

To collect these data, eight oceanographic buoys of the Antisubmarine Warfare Environmental Prediction System (ASWEPS) program will be utilized. Each buoy will telemeter information from a series of 25 temperature sensors located between the surface and a depth of 1000 feet over a period of six months. They also will report wind speed and direction, air temperature, and barometric pressure. By locating the buoys in a grid network in a limited area, it is possible to establish the nucleus of a three-dimensional measurement system for ocean-dynamics studies while at the same time accomplishing necessary test and evaluation of the instruments themselves.

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

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

Navy Laboratory Ship Operations

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

On the Naval Research Reserve

FOURTH NAVAL DISTRICT REPORTS

Reserve Officer Wins $32,000 Science Award

RADM Harry Hammond Hess, USNR, recently was awarded the 1966 Feltrinelli Foundation prize of 20 million lire. The bestowal, amounting to $32,000, is made annually by the Accademia dei Lincei, of Italy, for work in the physical, mathematical, and natural sciences. The admiral was awarded the prize for fundamental contributions to the study of ultra-basic rocks, island arcs, and submarine geology.

In 1949, the admiral (then a captain) became a charter member of Naval Reserve Research Company 4-1, Princeton, N.J., and he continued in the unit until 1961, when he was promoted to flag rank. He now has a mobilization assignment as Deputy Commander of the Naval Oceanographic Office, Suitland, Maryland.

In civilian life, Admiral Hess is head of the Department of Geology at Princeton University. He is a graduate of Yale, took his Ph.D. at Princeton, and later was a visiting professor at Capetown University in Africa. In 1936 and 1937, he served on the submarine BARRACUDA.

The Feltrinelli Foundation was established by Dr. Antonio Feltrinelli upon his death in 1942. He left a legacy to institute a fund for awards to be conferred upon scholars for outstanding work in history, literature, art, and medicine, as well as in the physical, mathematical, and natural sciences.

niral Hess and other Reserve officers present at NRRC 4-1's fiscal-year 1966 annual inspection: From left ight, CAPT Baker, CAPT Trost, CAPT Logan, RADM Hess, CAPT Bloom, CDR Reichard, LCDR Kearns, PT Gurin, and CAPT Tomlinson.

Princeton Unit Recruits Junior Officers

Early in fiscal year 1966, NRRC 4-1, Princeton, New Jersey, was at the crossroad. Members asked themselves, "Should we continue with a declining membership, most of which consisted of top-notch performers, or should we attempt to recruit new members at the risk of lowering our performance grades?" Membership had dropped to 26 officers, ten of whom might retire soon. The unit decided to try an all-out recruitment drive and, hopefully, to affiliate or develop performers who were equally as good as those who might soon leave the unit.

Since then the Bureau of Naval Personnel Report 1080-103, a list of local reserve officers not affiliated with a reserve program, was obtained from the local supporting training center and was aggressively worked and reworked. The results were not immediate, but as a consequence of this effort, a total of 20 officers received or are awaiting COM FOUR's endorsement to affiliate with NRRC 4-1. The rank distribution thus gained is impressive in the number of junior officers affiliated; newly assigned officers by rank are one ensign, eleven lieutenants (junior grade), seven lieutenants, and one lieutenant commander.

As a result of general announcements and advertising, officers under official cross-service training orders have increased to six Army Reserve officers and one Air Force officer. Although these officers do not count for competitive purposes, the unit considers them a valuable asset. Their contribution has created a high spirit and fostered an awareness of the problems and technical approaches of our sister services.

Despite the difficulties new men have in establishing homes and their civilian careers, the attendance factor has moved up some eight percentage points, and the active-duty training participation has increased 200 percent.

During the past fiscal year, members from NRRC 4-1 have served as judges for the Navy Science Cruiser Award at both the Greater Trenton and the Central Jersey Science Fairs. The members also have cooperated with the Naval Oceanographic Office in submitting comments on its proposed Ocean Science Study Kits. This project started at the October 1965 annual meeting of the Naval Reserve Association, at which it was resolved that "the Navy Department make available oceanographic educational materials to educational institutions, especially high schools and libraries." The Navy Oceanographic Office has assembled kits which will become available to our high schools and libraries commencing this fall.

Joint Meeting of Fourth Naval District Units

Air and antisubmarine warfare research problems and solutions confronting the Naval Air Development Center in Johnsville, Pennsylvania, highlighted a joint meeting of two Pennsylvania Naval Reserve Research companies on April 30, 1966. Members of NRRC 4-4, based at State College, and NRRC 4-12, located at Willow Grove Naval Air Station, toured the Development Center, where they were given an intimate look at various air and antisubmarine warfare research projects.

The keynote speaker of the day-long meeting was Dr. R. M. Chambers, a leader in aerospace research. Dr. Chambers, head of the Psychology Division of the Center's

Members of NRRC 4-4 and NRRC 4-12 discuss a card reader, part of the Control Data Corporation's 3200 Computer, which was installed at NADC, Johnsville. From left to right, they are CDR Pobst, LCDR Dean, CAPT Marboe, and CDR Burich.

Aerospace Medical Research Department, spoke to the Reserve officers on human-engineering considerations in space travel and space-flight simulation. He has worked closely with Mercury and Gemini space-project astronauts during their simulated environmental tests in the human centrifuge at the Development Center.

NRRC 4-4 is commanded by LCDR J. C. Dean, USNR, of State College, Pa., staff engineer of HRB-Singer, Inc. CDR John P. Burich, USNR, of Wyncote, Pa., commands NRRC 4-12. He is associated with the Naval Air Development Center.

State College Unit Establishes Award

NRRC 4-4, State College, Pennsylvania, established a new award this June for an outstanding Reserve midshipman graduating from the NROTC program at the Pennsylvania State University. The award, to be presented annually, cites a Reserve midshipman for aptitude and academic achievement, as well as outstanding leadership and devotion to duty in the four-year NROTC course.

The award includes a Naval Officer's Guide, Watch Officer's Guide, Division Officer's Guide, and a Navy tie bar and cuff link set.

EIGHTH NAVAL DISTRICT REPORTS

District Units Contribute to International Science Fair

The International Science Fair presented top awards to the most promising student-scientists of the year. The Fair, which is conducted annually, was held this year in Dallas, Texas, May 11-13. The areas of competition included botany, chemistry and biochemistry, earth and space sciences, medicine and health, physics, mathematics and computers, and zoology.

This year marks the first year that the Office of Naval Research had overall coordinating responsibility for the Navy role in the Science Fair. CDR Orval D. Hughes, USNR, commanding officer of Office of Naval Research Branch Office, Chicago, was the chairman of judges. Officers from Naval Reserve Research companies within the Eighth Naval District most ably contributed their professional talents as follows:

Subject	*Judges*	*NRRC*
Chemistry	CAPT Joseph R. Liles	8-4, Houston
	CDR Milton "G" Gugenheim, Jr.	8-4, Houston
	CDR James C. Stallings	8-4, Houston
	LT B. J. Gleason	9-5, Ames
Biological Sciences	LCDR Thomas N. Whitaker	8-4, Houston
Physics	LT Paul D. Maycock	8-12, Dallas
	CDR F. D. Colegrove	8-12, Dallas
	LCDR Floyd L. Cash	8-12, Dallas
	CDR Louis F. Connell, Jr.	8-12, Dallas
Mathematics	LT Martin D. Secker	8-5, Austin
	LT Paul H. Lorrain	8-12, Dallas
	LCDR Constance J. Jones	8-5, Austin

Space Science	LT Bobby N. Townsend CDR Daniel W. Wildfong	8-4, Houston 8-12, Dallas
Botany and Zoology	CAPT Walter H. Thames, Jr.	8-3, College Station

In addition to furnishing support to the Fair, the Eighth Naval District will host two of the seven Research Reserve seminars to be conducted in the U.S. during the next fiscal year—namely, Third Research Reserve Seminar in Applied Research, Albuquerque, New Mexico; and Research Reserve Electronics Computers Seminar, College Station, Texas.

Los Alamos Company Assists in Navy Science Cruiser Program

The recent transfer of the Navy Science Cruiser Program from the Bureau of Naval Personnel to the Office of Naval Research found NRRC 8-9, Los Alamos, New Mexico, already actively engaged in helping to select Science Cruiser award winners. Members of NRRC 8-9 have participated in judging for the past four years and have judged at regional, State, and international science fairs. For the past three years, CAPT R. J. Lanter, USNR, has presented the Navy Science Cruiser award at the State Science Fair, and previous to that, CAPT Alvin R. Lyle, USNR, presented the awards. Both captains are members of the local Research Reserve unit.

In this year's competition, the exhibit of Henry Garrett, principal award winner, which also won first place in the physical sciences division of the State Science Fair, was titled "A Photometric and Photographic Study of Asteroids." Later, he was selected as one of the ten Navy Science Cruiser Award winners at the International Science Fair held in Dallas.

The judging activity entails considerable travel for the members of NRRC 8-9. The Regional Science Fair is held in Las Vegas, New Mexico, about 100 miles away, and the State Science Fair is held in Socorro, New Mexico, 180 miles away. However, helping young scientists to become aware of the Navy is of such importance to members of NRRC 8-9 that they have volunteered their services to assist in this worthwhile program.

Shown at the New Mexico State Science Fair are CAPT Robert J. Lanter, USNR (right), with alternate Russell Lenth of Albuquerque (left); first alternate Ross Lemons of Los Alamos; and principal award winner Henry Garrett of Roswell.

* * *

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NRRC 3-9 Sponsors Joint Meeting

On June 1, 1966, NRRC 3-9, Brookhaven National Laboratory, Upton, New York, hosted a joint meeting of several local Reserve units. Naval Reserve units represented were Surface Division 3-32, SeaBee Division 3-19, NROS 3-6, Composite Company 3-43, and Dental Company 3-2. These five units, plus the host Research Company 3-9 (commanded by CDR L. Baker, USNR), constitute Naval Reserve Group 3-10. Several officers from NRRC 3-2, which meets at the Navy Special Devices Training Center in Sands Point, also attended.

The meeting was highlighted by a lecture by Dr. V. Bond entitled, "The Program of the BNL Medical Research Center." Dr. Bond, Chairman of the Medical Department at BNL, is Executive Officer of NRRC 3-9. Also attending this joint meeting was CAPT B. Osthues, USN, Commander of Naval Reserve Group 3-10.

Congratulations were in order for Dr. Bond upon his selection for promotion to captain, USNR, and to Dr. Robert Conard upon his selection to rear admiral, USNR.

Promotion Selections

Three thousand four hundred and thirty-two Naval Reserve line officers were selected for promotion to lieutenant by the fiscal year 1966 Reserve Selection Boards. Twenty four of these officers are Research Reservists. These officers and their companies are listed below:

FOR LIEUTENANT

	NRRC		*NRRC*
Alden, David G.	6-1	Noblitt, Gaylord C.	12-9
Beynon, David J.	9-25	Persons, Dayton S.	9-21
Bigger, Alvin J.	6-2	Platt, Rutherford H.	9-1
Cortelyou, Robert J.	12-6	Reynolds, John M.	12-3
Dearth, Andrew H.	1-1	Richardson, John A.	13-3
Deckard, Gerald A.	1-1	Ricketts, James R.	9-4
Gavin, John V.	1-1	Rowe, Raymond A.	11-5
Haley, Michael C.	8-9	Scholl, Raymond F.	5-10
Huber, Duane A.	8-4	Starr, Eugene L.	13-1
MacNeil, Nicholas	4-1	Supancic, John A.	5-9
Nazzaro, David A.	3-5	Watko, Laurence P.	9-5
Nickles, David E.	4-5	Weiler, Wayne B.	9-1

Date of Rank	*Designator*
4-14-51 Earliest	1105:20
1-31-64 Latest	1315: 1
5-17-63 Median	1405: 2
	5105: 1

Year of Birth	*Education*
1922 Earliest	Masters—5
1941 Latest	Bachelors—18
1940 Median	College Training, No Degree—1

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Editor: **RICHARD D. OLSON** **NAVSO P-510**

A set of mechanical "muscles" similar to the one shown in this mockup is being constructed for the Navy to allow a man to lift 1500 pounds while exerting only 40 pounds of force. The machine, called "Hardiman," will be attached to a worker's feet, forearms, and waist, enabling him to perform such tasks as loading bombs on aircraft, moving supplies aboard ship, and lifting heavy objects during underwater salvage operations. Hardiman is being constructed by the General Electric Research and Development Center, Schenectady, New York, under a contract with the Office of Naval Research. The original idea for such a device was conceived by the Cornell Aeronautical Laboratories, Buffalo, New York, also under a contract with ONR.